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ANNUAL REPORT

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OF THE

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c

GEOLOGICAL SURVEY OF NEW JERSEY.

BOARD OF MANAGERS.

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STATE GEOLOGIST.

GEORGE H. COOK.

To His Excellency, Theodore F. Randolph, Governor of the State of New Jersey, and President of the Board of Managers of the State Geological Survey:

SIR :—I have the honor herewith to submit my annual report, on the work of the Geological Survey, for the year 1869.

With high respect and esteem,

Yours truly,

GEO. H. COOK,

State Geologist.

RUTGERS COLLEGE,
New Brunswick, Dec. 28, 1869.

REPORT.

DISTRIBUTION OF THE GEOLOGY OF NEW JERSEY.

At the date of the last report, the Geology of New Jersey with the accompanying maps was passing through the press. Two thousand copies of the work were printed, and of these one thousand copies were bound. Since then five hundred more have been bound. The remainder are still in sheets. One thousand copies of the accompanying maps were colored and put up in portfolios, and the engraved stones were kept for further use. Since that time five hundred additional sets of the maps have been printed and prepared for distribution.

A large Geological Map of New Jersey on a scale of two miles to one inch, was also prepared, and two hundred copies were printed and colored. One hundred of these have been backed and mounted and the second hundred must soon be prepared, as the first is nearly gone.

According to your instructions, copies of the Geology and Maps have been given to various public officers and institutions, and others have been sold at the cost of paper, printing and binding. The price in this way put upon the book was very low, so low indeed that it left nothing to cover the cost of selling, and, of course, no inducement for booksellers to engage in its sale. The explanation you gave for this very low price, viz: that it saved from any invidious distinctions in distributing a few copies among the many who might desire it, and also placed it at a cost so moderate that any who chose could buy it, appears to be entirely satisfactory. There is no trouble in selling out the entire edition to booksellers, who would then be able to put it at a price which would pay them a profit. As the results of the Survey are intended for the benefit of the people of the State, it is undoubtedly best to continue the books at the same price as heretofore, for some time to come. It may be desirable to put them in the hands of booksellers, and raise the selling price, after the offer of them at the present rates has been continued for a sufficient time. The prices at which they have been sold are given in the accompanying descriptive list:

Geology of New Jersey, 899 pages large octavo, illustrated by 108 photolithographic engravings and wood-cuts, and six mine maps; and accompanied by a portfolio containing the following maps, in sheets:

1. Azoic and Paleozoic Formations, including the Iron-ore and Limestone districts; colored. Scale 2 miles to an inch.
2. Triassic Formation, including the Red Sandstone and Trap-rocks of Central New Jersey; colored. Scale 2 miles to an inch.
3. Cretaceous Formation, including the Greensand Marl Beds; colored. Scale 2 miles to an inch.
4. Tertiary and Recent Formations of Southern New Jersey; colored. Scale 2 miles to an inch.
5. Map of a Group of Iron Mines in Morris county; printed in two colors. Scale 3 inches to 1 mile.

6. Map of the Ringwood Iron Mines; printed in two colors. Scale 8 inches to 1 mile.

7. Map of the Oxford Furnace Iron-ore Veins; colored. Scale 8 inches to 1 mile.

8. Map of the Zinc Mines, Sussex county; colored. Scale 8 inches to 1 mile.

Price of the book and portfolio of maps, $6.00.

Geology of New Jersey, as above, without portfolio of maps, but containing a folded and colored map of the State, on a scale of 5 miles to 1 inch. Price $4.00.

Single copies of either of the above maps, colored and in sheets, 50 cents.

Geological Map of New Jersey, on a scale of 2 miles to one inch; colored and mounted on rollers. It gives the Geology of the State the same as Maps 1, 2, 3, 4, in the portfolio, and is essentially these combined in one map. Size 5½ by 7½ feet. Price $8.00 per copy.

The prices are fixed to merely cover the cost of paper, printing and binding; the expenses of the Survey and preparing book and engravings being paid by the State.

These publications can be had from Prof. Geo. H. Cook, State Geologist, New Brunswick, on remitting the price, or through the booksellers.

The books are also kept for sale at these prices by William T. Nicholson, of Trenton; Sampson & Morgan, of New Brunswick; M. R. Dennis & Co., of Newark, and D. Van Nostrand, of New York city.

The work is in the following public libraries, where it can be consulted:

In all the State libraries; in some other of the large public libraries in different parts of the United States, and in the following libraries in New Jersey and in the adjacent cities of New York and Philadelphia, viz:

New Jersey State Normal School;
New Jersey Model School;
Farnum Preparatory School;
West Jersey Academy;
Pennington Seminary;
Drew Seminary;
Newark High School;
Newark Academy;
Rutgers College;
Burlington College;
Princeton College;
Princeton Theological Seminary;
Theological Seminary of Reformed Church;
New Jersey Historical Society;
Seton Hall;
Newark Library;
Burlington County Lyceum;
Winslow Lyceum;
Camden Library;
Salem Library;
Dennis Library at Newton;
Tuckerton Library;
Millville Library;
Bricksburg Library;
Yardleyville Library;
Burlington Library;
Rancocas Library;
Woodbury Library;
Young Men's Christian Association of Trenton;
Young Men's Christian Association of New Brunswick;

Young Men's Christian Association of Hackettstown;
Young Men's Christian Association of Jersey City;
Home for Disabled Soldiers;
Home for Soldiers' Children;
American Iron and Steel Association, Philadelphia;
Philadelphia Library;
American Philosophical Society, Philadelphia;
Academy of Natural Sciences, Philadelphia;
New York Historical Society;
Astor Library, New York;
Mercantile Library, New York;
Cooper Union Library, New York;
Mechanics' and Tradesmen's Library, New York;
New York Lyceum of Natural History;
American Institute, New York;
American Geographical and Statistical Society, New York;
Long Island Historical Society, Brooklyn;
University of New York;
Columbia College, New York.

A copy of the Geology and two of the large mounted maps, were also offered to each of the County Clerks for deposit in their offices; one of the maps to be hung in the court room, and the other in the Clerk's office. Under this offer the book and maps have been sent to the counties of

Atlantic,
Bergen,
Burlington,
Camden,
Cape May,
Cumberland,
Gloucester,
Mercer,
Middlesex,
Morris,
Passaic,
Somerset,
Union,
Warren.

And they will be sent to

Essex,	Monmouth,
Hudson,	Ocean,
Hunterdon,	Salem,
Sussex,	

on application from the County Clerk.

It has also been supplied to the following Farmers' Clubs for their libraries:

Progressive Farmers' Club, Mt. Laurel;
Vineland Agricultural Society;
Somerset County Farmers' Club;
Seaville Farmers' Club;
Union County Farmers' Club.

And it will be furnished to any others in the State, which give promise of permanency, on their application.

It is desirable that every public library in the State should have a copy of the work, and it will be forwarded on application from the proper authority.

EXPENSES.

The expenses of the survey for the year have been $3,977.14, a sum considerably within the amount appropriated.

CONTINUATION OF THE SURVEY.

In accordance with the provisions of the law of last winter (1869), the survey is continued.

The State Geologist appointed in the original law of 1864, continues his supervision of the survey. The Assistant Geologist, Professor J. C. Smock, is, for the present, detached from the work, to extend his knowledge of

Geology and Metallurgy, by study and travel in Europe. It is expected that the survey will have the benefit of his studies and experience in preparing the report on the Iron and Zinc Ores.

Edwin H. Bogardus, the chemist of the survey, has been steadily engaged in the laboratory. He has completed the analysis of a large number of soils, in preparation for that part of the work, and has in addition analysed many fertilizers, clays, marls, &c., and is making experiments on the chemical changes that take place in various composts and rotting manures.

Edward A. Bowser, a graduate of our State Agricultural College, has been employed since the middle of September in a survey of the Newark and Elizabeth undrained marshes, and the reclaimed marshes of Salem, and a survey of Passaic river, with its branches, the Whippany and Rockaway, above Little Falls.

PLAN OF THE WORK.

The chief operations of the Geologist and his assistants, will be directed to putting the results of the survey in form for practical use. In carrying out this leading idea the investigations and conclusions will be arranged and published under the following general heads.

1. *Fertilizers found in the State, and the means of making them more quickly and generally useful.*

Under this head will come the results of those inquiries, investigations and experiments, which are so much needed for our advancing agriculture. The State has inexhaustible supplies of phosphatic and calcareous marls, of rich alluvial and marine deposits, and of fish and other fertilizers from the sea and its bays, sounds and creeks, which our farmers should know how to use at the earliest possible time, and in the most economical way. There is also an enormous waste of fertilizers in our towns and cities, which can be saved with great benefit, to both public health and agricultural productiveness.

2. *On the Marshes, and Tracts of Land subject to Protracted Freshets.*

There is a large area of land of this kind in the State, the improvement of which is demanded by the public interests. It is held in small tracts, so that the owners are not in power to carry out plans for its drainage; and information regarding its formation and condition, its capabilities and the means for its reclamation, is of large and general importance.

3. *On the Soils of the State, their origin, chemical and physical properties, distribution, and suggestions for their most productive management.*

With a full third of the State unimproved, and in condition to be successfully treated, by the intelligent use of capital, it is plain that this subject should be made a matter of scientific investigation.

4. *On the Iron and Zinc Ores of the State.*

In the *Geology of New Jersey* this subject is taken up in connection with the rock formations of the State. The origin of these ores, the chemical changes they have undergone, their rock and mineral associations, the geological changes to which they have been subjected, their present occurrence, and the modes of searching for, and of mining, are all treated of in that work, but under different general heads. They deserve a distinct and separate examination and description.

5. *Additions to the Scientific and Economical Geology of the State.*

Every year is adding to the stock of knowledge upon these topics, and it is of importance to have this knowledge made public as extensively and as early as possible.

I. FERTILIZERS FOUND IN THE STATE, AND THE MEANS OF MAKING THEM MORE QUICKLY AND GENERALLY USEFUL.

The mineral and other fertilizers found in the State have been described in much detail in the Geology of New Jersey, and in the Annual Reports of the Agricultural College. I present here some analyses of Greensand Marl, and tables for their valuation as fertilizers :

ANALYSES.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Phosphoric Acid.......	1.14	3.58	2.58	3.87	1.33	1.02	2.30	2.24	2.69	2.56
Sulphuric Acid.........	0.14	0.97	1.89	.31	.00	.27	.00	.39	.26	0.22
Silicic Acid............	38.70	53.15	59.80	54.75	46.03	50.23	57.67	50.80	49.40	51.50
Carbonic Acid.........	6.13	......	.....	......	......	.....	......	......	.....	.....
Potash.................	3.65	3.75	4.25	4.11	5.67	6.32	3.53	5.18	6.31	4.62
Lime..................	9.07	3.27	2.97	5.46	2.01	1.40	1.26	2.13	2.52	1.26
Magnesia...............	1.50	1.75	2.00	2.99	3.47	3.45	3.67	3.54	3.24	3.95
Alumina	10.20	8.79	6.00	6.46	7.86	7.94	10.10	8.77	8.90	6.01
Oxide of Iron..........	18.63	15 94	11.98	15.20	25.23	20.14	14.16	17.63	17.11	21.04
Water..................	10.00	8.98	8.32	6.85	8.40	9.00	7.25	9.66	9.10	7.39
	99.16	100.18	99.79	100.00	100.00	99.77	100.00	100.34	99.53	98 55

(1) Is an average of the variety of marl most largely used in eastern Monmouth. It is not particularly rich in phosphoric acid, but is remarkable for containing from 10 to 20 per cent. of carbonate of lime in fine powder. In the neighborhood of this marl where it costs little more than the cartage, a great deal is used, which is much poorer than this; but there is no trouble in finding millions of tons of this quality. It is used in larger quantities per acre than the other varieties, and is remarkable for the permanent improvement it makes in the soil.

(2) Is an average of five analyses of the *Squankum* marl, and may be taken as a fair sample of that noted fertilizer. The specimens for analysis were taken from five different pits, and each was judged to be an average of the whole digging.

(3) Is an average of the marl dug by the Squankum Marl Company. It is supplied of this quality along the entire line of the Raritan and Delaware Bay Railroad, and also at Port Monmouth for shipping. This marl is dug from the green and ash layers of the upper marl bed. The ash marl is more clayey and poorer than the green marl. But the mixture of the two is a good fertilizer, as both experience and the analysis show.

(4) Is an analysis of an average sample taken from a pile of 100 tons of marl sent by the Freehold and Squankum Marl Company to New Brunswick. A sample carefully averaged by my assistant, Mr. Bogardus, at the pits of the Company, yielded $4\frac{58}{100}$ per cent. of phosphoric acid.

(5) Is from the pits of the Cream Ridge Marl Company. The analysis is from an average specimen taken at the pits by my assistant, Mr. E. H. Bogardus.

(6) Is from the pits of the Pemberton Marl Company.

It was from a sample prepared by J. C. Gaskill, Superintendent, and was averaged by cutting an uniform slice from the top to the bottom of the bank of marl, and carefully mixing the whole.

(7) Is an analysis from the pits of the Vincentown Marl Company. The sample I believe to be a fair average.

(8) Is an analysis of marl dug at White Horse, on the line of the Camden and Atlantic Railroad. An abundant supply of this marl is to be had; and it is the source from which it can be easiest sent to all of Atlantic county, and the country along the Camden and Atlantic Railroad.

(9) Is the analysis of a carefully averaged sample of marl from the West Jersey Marl Company's pits at Barnsboro'. Several hundred tons of it are sent over the West Jersey Railroad every day, to supply the wants of farmers in the country traversed by that road and its branches. The growing demand for this marl is the best proof of its good quality. It is from the green layer of the middle marl bed.

(10) Is an analysis of an average sample of marl from the pits of Dickinson Brothers, at Woodstown. This marl has an excellent reputation. From 10,000 to 15,000 tons are sold annually to the neighboring farmers, and hauled away in wagons.

Tables for Calculating the Value of Marl, and for Comparing it with other Fertilizers.

TABLE I.

Stockhardt's Table of the gold values of the chief elements in fertilizers, copied from Caldwell's Agricultural Chemical Analysis.

Form in which the substance exists in the fertilizer.	PRICE PER LB. IN GOLD.
Phosphoric Acid, soluble in water as in super phosphate,	$ .12½
Phosphoric Acid in Peruvian guano,	.10
Phosphoric Acid in steamed bones finely ground, in rape cake, poudrette, etc.,	.08¼
Phosphoric Acid in Baker guano,.	.07½
Phosphoric Acid in coarse bone-meal, fresh human urine, etc.,	.07
Phosphoric Acid in coarse broken bones, fresh human excrements, stable manure, etc.,	.05½
Potash as potassic sulphate,	.06½
Potash as potassic chloride and in other forms,	.05½
Nitrogen easily soluble, or in compounds that are readily decomposed, as in ammonia nitrate, dried blood, meat, urea, etc.,	.22
Nitrogen in finest bone-meal, poudrette, etc.,	.19½
Nitrogen in coarse bone-meal, rape-meal, horn-meal, wood-dust, fresh human urine, etc.,	.16½
Nitrogen in coarse broken bones, horn shavings, woolen rags, fresh human excrements, stable manure, etc..	.13¾

TABLE II.

The English valuation of these substances is given in Vol. 20, p. 74 of the *Country Gentleman*, by Dr. Voelcker, Consulting Chemist to the Royal Agricultural Society of England. It is as follows, allowing two cents for each English penny:

1.	Nitrogen in the form of ammonia,	16	cts. ℘ ℔
2.	Nitrogen in animal or vegetable substances,	12	"
3.	Nitrate of Soda,	4	"
4.	Phosphate of Lime, (bone earth),	2	"
	or Phosphoric Acid alone,	4	"

		PRICE PER LB. IN GOLD.
5.	Soluble Phosphate of Lime, or Bi-Phosphate of Lime,	9 cts. ⅌ ℔
6.	Salts of Potash,	2½ "
7.	Gypsum.	2 cts. ⅌ 10 ℔
8.	Lime,	2 " 12 "
9.	Carbonate of Lime,	2 " 25 "
10.	Magnesia,	2 " 10 "
11.	Organic matter, (humus),	2 " 20 "
12.	Common Salt	2 " 10 "

PRICES BY PROF. JOHNSON.

Professor S. W. Johnson, of New Haven, Connecticut, in a report to the Secretary of the State Board of Agriculture on Commercial Manures, made last winter, estimates the gold value of potash, at 4 cents a pound; soluble phosphoric acid at 12½ cents; insoluble phosphoric acid 4½ cents, and nitrogen 17 cents. Professor Johnson is the best authority on this subject, in our country.

By the use of these tables the approximate value of the marls may be calculated.

The phosphoric acid is combined mostly with lime, though a little of it is probably combined with oxide of iron. The phosphates of lime and iron are both in very fine powder, or else in soft grains, so that while it cannot be quite as soluble as superphosphate, it is certainly much more soluble than any bone-dust. Judging from Stockhart's table of prices and qualities of fertilizers, I think the phosphoric acid in our marl should be rated between that in guano, which is 10 cents a pound, and that in steamed bones, which is 8½ cents, and therefore propose for it in our calculations, 9 *cents gold as the price per pound.* The potash in the marls is combined with silicic acid, and the compound, silicate of potash, is not readily soluble in water. Johnson's price, 4 cents a pound, is for soluble potash as it is found in carbonate of potash (pearl-ash), sulphate of potash, muriate of potash (chloride of potassium), or crude potash. The potash in the marls is, however, dissolved out slowly by the action of water containing carbonic acid, and so becomes available. Until there is some more decided reason for fixing a different price, I will set down its value at 2 cents a pound.

The value of the several marls given in the above table would then be easily made. Considering the phosphoric acid and potash as the only parts of the marl worth transportation, their values range from $3.50 to $8.50 a ton; and I believe, that in comparison with the prices paid for concentrated manures, they are worth that price to the farmer. The cost must be taken when they are upon the soil, and not, as might be thought, when in store. I am confirmed in my opinion of their value by the testimony of successful farmers, who have used them for twenty years or more; and who assure me, they can better afford to incur an expense from $5 to $8 a ton, than to farm without them or to use any other purchased fertilizers; and also confirmed by my own observation in all parts of New Jersey where marl has been used. It gives lasting fertility to the soil. While all other fertilizers are exhausted and the soils become poor, I have to see the first field that has ever been well marled that is now poor. One instance was found where poor and sandy land was marled more than thirty years ago, and has ever since been tilled without manure, and not well managed, which is still in good condition. Occasionally marled fields are seen that do not grow crops as large as they once did, but all their fertility is immediately restored by a dressing of lime; an effect which could not have been produced by the lime on unmarled land.

I am averse to having the valuation on the various green sand marls which are used in the State, based on the phosphoric acid and potash only in the above table of analyses; for I do not think they are the only useful substances in it. The fine carbonate of lime in No. 1, is certainly of too much value to be neglected. And the sulphate of lime (gypsum) in many of them is enough to be very beneficial to crops. The valuation, however, seems to be demanded, and this is the best approximation I can make.

Table showing the estimated value of the Phosphoric Acid and Potash in the ten samples of Marl analysed.—Marl contains no Ammonia.

No	Phosphoric Acid.			Potash.			Total Value per ton
	Per cent.	Per Ton. Pounds.	Per Ton. Value.	Per cent.	Per Ton. Pounds.	Per Ton. Value.	
1	1.14	22.8	$2 05	3.65	73.0	$1 46	$3 51
2	3.58	71.6	6 44	3.75	75.0	1 50	7 94
3	2.59	51.6	4 64	4.25	85.0	1 70	6 34
4	3.87	77.4	6 96	4.11	82.2	1 64	8 60
5	1.33	26 6	2 39	5.67	113.4	2 27	4 66
6	1 02	20.4	1 83	6.32	126.4	2 53	4 36
7	2.33	46.6	4 19	3.53	70.6	1 41	5 60
8	2.24	44.8	4 03	5.18	103.6	2 07	6 10
9	2.69	53.8	4 84	6.31	126.2	2 52	7 36
10	2 56	51.2	4 60	4.62	92.4	1 85	6 45

Other Fertilizers in Comparison.

An average sample of *Peruvian Guano* may have its value calculated in the same way, and if we use Johnson's prices, considering also 14 cents for ammonia to be equal to 17 cents for nitrogen, and the phosphoric acid as equal to soluble, the result is:

For 15 per cent. ammonia, or 300 pounds per ton,	$42 00
For 5 per cent. potash, or 100 pounds per ton,	4 00
For 10 per cent. phos. acid, or 200 pounds per ton,	25 00
Total gold value for one ton, ...	$71 00

A first quality Super-Phosphate.

For 7. per cent. Ammonia, or 140 lbs per ton,	$19 60
For 6.5 per cent. Soluble Phos. Acid, or 130 lbs. per ton.	16 25
For 5. per cent. Insoluble Phos. Acid, or 100 lbs. per ton, ...	4 50
Total gold value per ton, ...	$40 35

Pure Raw Bone.

For 5 per cent. of Ammonia, 100 lbs. per ton,	$14 00
For 25 per cent. of Insoluble Phos. Acid, 500 lbs. per ton, ...	22 50
Total gold value per ton, ...	$36 50

Marl, and by this term I always mean greensand marl, unless it is otherwise expressed, is a mineral substance and not very easily or rapidly dissolved, and it does not appear to have any unusual power of absorbing ammonia. As part of the value of a fertilizer depends upon its solubility, it becomes of prime importance to the farmer to quicken the solubility of marl as much as possible. Composts of marl with lime, or barn-yard manure or guano, produce this effect, and where the experiment has been thoroughly tested by farmers, it has proved highly satisfactory.

Experiments are in progress to determine the chemical effects produced upon marl by composting, and some advance has been made; but the results are not yet complete enough for publication. Experiments and inquiries are also in progress, to see if any process can be devised for separating the phosphoric acid and potash from the mass of the marl, and so put in a more concentrated form for transportation to distant places, at less cost.

II. ON MARSHES AND TRACTS OF LAND SUBJECT TO PROTRACTED FRESHETS.

The marshes along the sea-shore, and tidal waters of the State, cover a large extent of surface. Nearly all of them are only waste ground, unproductive, unsightly, and directly under the eye of the public. These marshes, if reclaimed, would be the most productive farm lands in the State; and the location of some of them in the immediate vicinity of New York City, where land is high priced, is creating a necessity for their entire reclamation at an early day.

It is remarkable that these marshes should have so long remained unimproved, when the success and value of such improvements was so well understood. Marshes in the vicinity of Salem were dyked and drained as early as the year 1700, and from that time to the present, such works have been continued, and profitably managed in that part of the State. To those engaged in the Geological Survey, the contrast between the rich and productive lands in the dyked grounds of West Jersey, and the waste and forbidding wild marshes of East Jersey, was very striking and suggestive. We cannot do better than to reprint here, an extract from the Geolocical Report of 1866, upon this subject. The successful improvement of the tide-marshes has been effected by shutting out the flow of the tide by embankments, and allowing the drainage to go on through sluices open only at low-water. By this means they are made dry, nearly to low-water mark. This work of banking in meadows has gone forward till the territory rescued from the sea amounts to 15,000 acres in Salem county alone besides large areas in Gloucester, Cumberland and Cape May counties. The largest tracts, and perhaps the most successfully managed, are in Salem county. The work has all been done by private enterprise; the owners of a tract that could be profitably enclosed by a single bank, associating themselves together, and carrying the work forward under the terms of the banked-meadow law.

For the improvement of such a tract it is necessary to get the consent of the owners of two-thirds of the acres included in it, before the work can be begun. The ground is then surveyed, the banks located, and the courses of ditches and streams arranged by disinterested parties, or commissioners, who are generally men of large experience in the system of meadow drainage. The first operation is to dig on the site of the proposed bank a trench four feet wide and two spits deep. By this means the sod and grass roots of the surface are removed, and there is a firm foundation made on which to raise the proposed bank. Then a ditch twelve feet wide and three spits deep is dug outside the trench, and on the side next the creek or other body of water. This supplies the material for the bank. The spits thrown out of the ditch are cut into small pieces, and fitted tightly together in the bank by the packer, just as stone are laid up in a wall. This mud when well packed, forms a very strong and durable bank so long as it is kept moist. If it gets too dry the bank will crumble down. But this is rarely the case, since the flood tides generally keep the banks on the outside quite moist, and even wet. The general size of the Salem banks is four feet high above the meadow, eight feet wide at the bottom, and three feet on the top. The slope is commonly one-half to one on the inside, and nearly one to one on the outside. Exposed situations require larger and stronger banks, as, for example, those on the wearing or concave shores of streams, or where there is danger of high tides, from wind and water conspiring together. Thus at Finn's Point, on the Delaware, in Lower Penns Neck, where there is a very exposed shore for two or three miles along the river, the bank is ten feet high, twelve feet wide on top, and thirty feet at the bottom. The top is wide enough for a wagon road. This mud bank is also protected by a facing of stone on the river side, which secures the whole against any dangers from washing by heavy waves and high tides. By this bank an area of 1,200 acres has been safely protected at an unusually exposed point. In Cumberland county the banks range from three to seven feet high, and are built immediately on the surface of the meadow.

The banks are built at a little distance from the edge of the stream, leaving a strip of marsh outside a rod or more in width, for the protection of the bank, and also for supplying the mud used in repairing. This space is called the *guard* or *shore.*

The cost of banking meadow varies greatly. Those built of mud from a ditch twelve feet wide and three feet deep, formerly cost $1 a linear rod; now they cost about $3 per rod. The banking of Fishing Island meadow, Lower Penns Neck, cost $10 an acre. Another tract brought in, in 1866, cost $15 an acre. The first is about the present average cost. Along Maurice river banking now costs $2 a linear rod, and upwards. These estimates by the acre include the whole expense of cutting drains and water-courses, in addition to the building of banks. For the proper drainage of the meadows, ditches are cut at intervals, varying with the needs of the meadow. These are generally seven feet wide and two feet deep. When they are intended as boundaries, they must be nine feet wide, or no suit for trespass can be maintained. Wide drains with sloping sides are found the best for securing complete drainage. Such meadows need constant attention, and require annually considerable outlay of capital for the necessary repairs of banks and drains, and improvements of the surface. The expense of their maintenance in good order, varies much with the degree of exposure. Generally the cost for repairs ranges from fifty cents to $1 an acre, yearly. The Finn's Point meadow costs on an average $2 an acre per year. Much of the expense is caused by the depredations of the musk-rat which burrows into and through the banks, rendering them peculiarly subject to breaks by high water. The ravages of these animals are met only at an enormous expense every year. To avoid as much as possible injuries from these pests, it is considered advisable to examine the banks at frequent intervals, and to dig out any holes found in them. This work is expensive, as it can only go on at low-water. Some companies employ a man one day each week to examine the banks and note the points needing immediate attention, thereby preventing breaks in the banks, which are so apt to occur where the muskrat has been at work. Another source of danger to the banks is the perforations of the soldier crab or *fidler*. These are very numerous, and their borings into the bank sometimes make it into a complete sieve, through which the water strains upon the meadows. Constant watching is required to prevent their damages. Besides these living enemies the meadow owner also has to contend against breaks from high tides, and from settling of banks. Nearly all banks require occasional additions to the top caused by crumbling of mud, or more frequently by the settling of the whole bank. Where they are built upon firm mud, as is commonly the case along streams, the amount of settling is very little, but where they cross a meadow, or form what is called a *cross-bank*, or run across an old water course, the settling is an item of much labor and expense. Some are known to have sunk down as much as ten feet in the same number of years. The cross-banks are more liable to settle, because of the thinness of firm mud covering the peaty mass beneath. Wherever built upon such peaty substratum, settling is inevitable, and continues until a solid bottom is reached. The settling is generally gradual, but instances are given, in which the bank has gone down at once out of sight. As long as tide-marshes are open, liable to be overflowed at high-water, and so kept soaked full, they remain nearly at the level of high-tide; but after banking and draining they become quite dry, and the spongy mass slowly decays, and is consolidated, thereby causing a sinking of the whole surface. Tillage hastens this subsidence by opening the mass to the action of atmospheric agencies, and by a large annual withdrawal in the form of crops. From these causes a slow and gradual settling is effected. In nearly all banked meadows the difference in heights of the outside *guard* and the enclosed meadow, is very perceptible. The constant silting of fine sediment upon the areas outside the banks, often brings them nearly up to the height of the projecting bank. And after a long series of years of cropping, the meadow settles down to low-water mark, and it becomes unprofitable for further cultivation, on account of imperfect drainage. To remedy this the banks are opened at several points, and the muddy water allowed to enter and deposit its sediment upon the surface. The thickness of this deposit varies exceedingly, some streams depositing much more than others in the same time. Maurice river and Salem creek carry down a large amount of mud, while Alloways creek deposits a mere film on the surface in one season. The meadows are left open to tide water for a period of from five to ten years, according to the rapidity of deposit. A meadow near the city of Salem which has been open to the tide for ten years has now a mud deposit covering it to an aver-depth of two feet. By this covering of mud the meadows are raised so as to be drained with more ease, and their quality is much improved; the grasses also are much more nutritious. This operation really covers the meadow with a new soil, and one of lasting fertility. Some meadows settle so little that they have been tilled regularly for the last seventy years, and it is said that on some the banks have been in repair for over a century. These are exceptional cases, however. To open the banks requires the consent of the owners of three-fourths of the included acres.

Another mode of counteracting the settling, and also of improving the meadow, is to allow the tides to enter during the winter, by opening the sluices. In this way a layer of muddy sediment is deposited all over the surface, which may vary from a mere film to twelve inches in thickness in one winter. The best and most practical meadow managers prefer this winter flooding of their meadows, as an improvement and counteraction of settling. By this mode there is no loss of the crops for five or ten years, which necessarily occurs when the banks are not closed. Others think that flooding is altogether useless; lime and superphosphates improve them, and there is no need of a fresh covering of sediment. But as the subsidence is certain wherever there is a peaty substratum of much thickness, flooding must be adopted, or else occasional dressings of marl or upland earth will be needed to keep up the height of surface above low-water mark. The frequent application of soil from the adjacent upland would also be a cheap and valuable amendment to these meadows, which contain an excess of vegetable matter.

These meadows are composed of earthy or vegetable matter, all of which has the common designation of *mud.* *Blue* and *grey* mud is a deposit of clayey substance, and is blue when wet and grey when dry and weathered. *Black* mud is fine muck, or disintegrated vegetable matter. *Horse-dung* mud or turf, is the fibrous and peaty matter that constitutes the spongy part of the marsh, and is nothing but a net-work of grass and sedge roots. In most of the meadows the blue mud rests upon the peaty mud. The grey mud is most abundant near the banks of streams. It would seem as if the blue and grey mud deposits of this region are of recent origin; as late as the settlement of the country and clearing of the forests. Streams now hold in suspension a much greater amount of mud than when the country was covered with woods.

The banked meadows of Salem and Cumberland are the very best of grazing lands, and furnish indirectly a vast amount of manure for the uplands. The lowest of them grow herds grass, which is raised for its seed. Salem is the great centre of the trade in this product, for our whole country. The average yield is about thirty bushels to the acre, and a common price for it is seventy-five cents a bushel. The stalks though not as good as hay, are valuable for fodder and litter. The care and expense of such lands is but very little, so that the crop may be considered a profitable one. The meadows along Maurice river are found suitable for the growth of timothy and grain and root crops, and enormous crops of these are grown from year to year without any manure. At Finns Point the yield of wheat is from thirty to forty bushels per acre, and of potatoes, from 150 to 200 bushels. The blue and grey mud soils are always good for any crop whatever. The black mud is not reliable for wheat, but Indian corn thrives on it. Lime acts like a charm on meadow everywhere. It is common to use it in dressings of 100 bushels an acre, with good effect; and there is one authentic case of 900 bushels having been used on one-third of an acre, and a large crop of corn being raised on it the same season.

The value of the banked meadows in Salem may average $100 an acre, some being worth $400 or $500, and others considerably less. On the Cohansey and Maurice rivers they are much more valuable than the adjoining upland, ranging in price from $50 to $200 an acre. Before they were banked these marshes were almost worthless. They yielded at the best salt grass or sedge, which may be used as a coarse fodder or for packing. In Lower Alloways Creek, Salem county, salt marsh bordering the Delaware is worth from $1 to $5 an acre. About Leesburg, Cumberland county, it sells for from $10 to $20 an acre. The common opinion among meadow men is, that all marsh which can be made to grow herds grass can be profitably banked where the cost of banking does not exceed $15 an acre. In short, all meadow or salt marsh that can be drained by open ditches, may be reclaimed with profit; and if it is two feet above low-water mark that is generally practicable. Where water is quite salt, as is the case near the ocean or mouth of the bay, the meadow will need two or three years to get freshened enough to grow anything except salt grass. Time will, however, in nearly all cases after banking, bring about such a change that herds grass may be raised, if not timothy and the clovers. The great point is to get drainage; the tides can be shut out no matter how high they rise. The question then is, how much is the marsh surface above low water? and if not too low banking is both practicable and profitable.

The following is a tabular statement, by counties, of the number of acres of tide meadows, fresh and salt, in the State:

Counties.	Number of Acres.
Bergen,	11,910
Hudson	12,896

Counties.	Number of Acres.
Essex,	4,282
Union,	4,446
Middlesex,	7,335
Monmouth,	5,958
Ocean,	31,155
Burlington,	25,429
Atlantic,	38,003
Cape May,	58,824
Cumberland,	51,078
Salem,	28,602
Gloucester,	9,958
Camden,	3,652
Mercer,	1,946
Total,	295,474

Of this great extent of marsh, only about 20,000 acres are inclosed by dykes, nearly all of which is along Delaware river and bay. The remaining 270,000 acres are still comparatively unimproved, and worthless for real agricultural purposes.

There are many of the salt marshes which contain too little earthy matter to be very solid, and the tide-water which flows over them is so free of sediment, that none is deposited. When the improvement of these is undertaken they will be found to sink to low-water mark very soon, and if the drainage is continued it can only be done by pumping, or otherwise lifting the water above tide-level, a work which has not been done in this country, but which experience in foreign countries shows to be both practicable and profitable. Holland, which has an area of near 12,000 square miles, has between 6,000 and

8,000 square miles of its surface included within banks or dykes, and it is kept dry enough for cultivation by raising all the water that gets on it from rain, springs and leakage, by pumps, to the height of five, ten, fifteen and in some extreme cases twenty-two feet. The land thus reclaimed is among the most productive in the world. The course of improvement began there just as it is beginning here. At first the marshes were dyked in, and drained by sluices, but as they sank away, it was found necessary to continue the work by draining the water down to a lower level, and then raising it in pumps by the force of wind, and so allowing the settling to go on until the marshes had become solid ground. In addition to the marshes, they have drained in the same way ninety lakes, the last of which, Harlem Lake, covered an area of 45,000 acres, and was, on the average, over twelve feet deep. This immense work required the raising of 1,000,000,000 tons of water, which was done in about four years, at a cost of $3,592,537, or not far from $80 an acre. The first sales of land in it brought $100 an acre, and it is expected that the whole amount of sales will equal the original cost. The annual drainage will require the raising of 54,000,000 tons of water.

On the north and northeast sides of England, there are immense tracts of reclaimed lands. The "Great Bedford Level," includes an area of 680,000 acres of the best land in England, which has been converted by drainage from a dreary waste into a fruitful plain. These lands are too low to be drained by sluices at low-water, and resort is had to pumps, driven formerly by wind-mills, but now chiefly by steam. The drainage is done effectually, and the power required to do it has been carefully calculated.

The rain fall there is twenty-six inches a year, or a little more than two inches a month. This is 7,260 cubic feet on an acre, and can be raised ten feet high in two hours and ten minutes by the power of one horse, or one horse power engine would drain 332 acres. Coleman says "that two steam engines, one of sixty and the other of eighty horse power, are effectual to the draining of 40,000 acres of what is called the *Deeping Fen.* The upper part of these lands, which are thus drained, was peat meadow, the lower part was salt marsh. These lands are now in the highest degree productive, yielding fine crops of wheat, oats, potatoes and swedes, besides furnishing the very best of pasturage and hay lands. There is found to be a difference in the qualities of the grass; the lowest lands are fed with sheep, and the highest with cattle. Barley is not cultivated on these lands, but besides the crops above mentioned, mustard, wood and chicory are extensively cultivated. Four crops of wheat in succession have been taken from these lands without manure. As the last crop was less than the former, the land was then laid down to grass. The rent of these lands is $8.55 and $9.00 per acre, but this must be considered as a moderate rent for lands so valuable. By means of these steam engines, the water is kept down to the required level. It is not found necessary to work them at all times, and the power is sufficient for any extraordinary emergency.

"A tract of about 6,000 acres in Nottinghamshire, on the Northern boundary of this county, called *The Carrs,* has been drained in a similar way. The general impression is that the sea once flowed over this territory. Half a century ago this morass was first attempted to be brought into cultivation. At that time it was absolutely a bog, and no horse could be used in ploughing it. The first attempts at draining it were not successful. In 1828 a steam engine of forty horse power was erected at a cost of $30.000 for lifting the water by a wheel. The engine is placed upon the main drain, at about three-quarters of a mile from the river Trent, into which the drainage of these Carrs empties itself; but unfortunately when high tide flowed up that river, there was frequent interruption to the drainage from the water in the river being higher than that in the drain, and it would have flowed in upon the Carrs had not flood gates prevented it. By placing the engine at some distance from the Trent, a reservoir was then formed in the main drain, within that space planked by high banks, and so by lifting the water into this reservoir to a higher level than the Trent, it is enabled to fall into that river at all times.

"The wheel for lifting the water revolves between two stone walls, in a space about twenty-seven inches wide, through which the whole of the water is driven. The wheel itself is formed of cast metal sides, with wooden paddles between, placed ingeniously at a certain angle, which enables the wheel to lift the water above its own centre; thus a wheel of thirty-three feet diameter creates an artificial drainage equal to more than its radius of sixteen and a half feet. Flood gates are again placed immediately before the wheel, to prevent the water coming back on the wheel ceasing to revolve. Absolute command of the water is now effected, and a provision has been made of incalculable value to the occupiers of these Carrs, by introducing during the summer months, water from the adjoining river Idle, as a supply for the stock. The total cost of two engines for the purpose of this drainage, has been little less than $60.000 dollars, and the annual expenditure of working the engines and cleansing the drains is from sixty-seven to ninety cents an acre."

Our marsh lands are as susceptible of improvement, and as productive when in cultivation, as those of England or Holland—and they are so near the great markets of our country that their improvement is a matter of necessity.

It would undoubtedly cost more labor to drain our marshes by pumping, than it does in England or Holland. Our annual fall of rain in New Jersey averages forty-five inches in depth, with an extreme variation, in different years, of nine or ten inches above or below the average. The annual rain-fall on the east coast of England averages twenty-six inches, and that of Holland thirty inches a year. These figures will enable any one who may desire to compute the amount of work needed to drain an acre, and to estimate its cost.

The New Jersey Land Reclamation Company have purchased and inclosed with a dike, the whole tongue of marsh at the head of Newark Bay between the Passaic and Hackensack rivers, and extending up from the Bay to Saw Mill Creek, covering an area of 6000 acres. The tide is now effectually shut out, and the water in the ditches stands very nearly down to low water mark. To protect the bank from the ravages of muskrats they put in it a core of thin cast-iron plates, which reach from a foot and a half above the surface to three and a half feet below. They have faced the exposed parts of the bank with stone, are cutting out and opening the ditches and drains, and have already plowed several hundred acres. The energy with which the company is prosecuting this enterprise is in the highest degree commendable, and the successful prosecution and completion of such a work in this place will do more for such improvements than it could anywhere else on the continent. They richly deserve all the advantages their admirably selected location can give them.

The cost of building dikes is likely to be materially lessened by the use of labor-saving machinery. Several banks have been built in Salem county within the last year or two, by the use of a steam dredging machine. It does work at a very moderate price, and in the place where I saw it operating, which was on the bank of Salem creek, in Lower Penns Neck, on Mr. Howard Sinnickson's meadow, it was doing work which could not have been done at all by hand labor, and was building a substantial bank at a cost not greater than that of any other good bank.

The success which has followed the banking of meadows in West Jersey, and the little progress made in such work in East Jersey, has led to the inquiry whether there is any reason for this difference on account of difference in the condition or quality of the marshes on the two sides of the State. To answer this inquiry, Edward A. Bowser, a competent surveyor and observer, was sent to sound, survey, and note the peculiarities of material in the marshes along the Hackensack and Passaic rivers and Newark Bay, and then for the comparison, to do a like work upon the banked meadows along the Delaware and its branches in Salem county. This survey has been completed, and maps of the marshes and meadows have been drawn out by Mr. Bowser. His report to me upon the subject is inserted here, and his maps are appended. I need only say in regard to it that the difficulties encountered in

Salem have been much greater than need be expected in the marshes of East Jersey, and that the quality of material for soil does not appear to be any better.

Report on the Tide Marsh on Newark Bay, and the Passaic and Hackensack Rivers.

"The accompanying map of the above named marsh represents the *nature* of the surface material and its *depth.* The sounding was done with a slender iron rod, in the months' of September and October, when the marsh was tolerably dry. In most places the material was very firm, requiring all the strength of *one* man, and sometimes of *two*, to put the rod down to the bottom. Especially was this the case where the material was blue clay or mud.

On the map the small figures denote the depths of the soundings down to a firm gravel, or sand bottom. The *short, straight, horizontal lines* represent blue clay; the *curved* lines represent peat or muck, which is simply peat or vegetable matter more or less decomposed; a mixture of *straight* and *curved* lines represent blue clay and peat, sometimes mixed, and at other times one overlying the other. The other signs used are explained on the maps.

By referring to the map it will be seen that the marsh between Elizabeth and Newark is mostly blue mud (clay) varying from seven to sixteen feet deep. The bottom is firm gravel. Near the upland, for a long distance, the clay is mixed with peat, and in some places as the Central railroad and near the New Jersey railroad on the northern edge of the marsh, it is all peat. The soundings in the peat and clay vary between three and eight feet.

Between the Passaic and Hackensack rivers, and south of the Morris canal, it is all blue clay and very firm, vary-

ing between eight and eighteen feet deep. It has a bottom of gravel.

Between the Morris canal and the New Jersey railroad, the map shows that on the Passaic side it is all blue clay, while on the Hackensack river it is blue clay and peat mixed, and up near the railroad and intermediate between the rivers, is the southern edge of an extensive cedar swamp. This blue clay is eighteen feet deep in some places, while the clay and peat mixed is not over twelve feet deep. Near the meeting of the railroad and the Hackensack river it is all *clay* again, and continues on up beyond the Morris and Essex railroad, varying from twelve to upwards of twenty-four feet deep.

North of the New Jersey railroad is a cedar swamp bottom, which extends from the Hackensack river to the upland, on both sides of the Belleville turnpike, and a narrow strip runs north nearly to Berry's creek. In this swamp the stumps in many places are so thick that it is difficult to run a rod down. The soundings vary from three to eight feet, with a sandy bottom. On the edge of this swamp the material is clay and peat, mixed, which on the west side extends to the upland, and a little north of the New York and Erie railway. Between this cedar swamp and the Hackensack river it is blue clay, in some places twenty-three feet deep, and extends, with the exception of a little cedar swamp near the upland and the Paterson plank road, up to Hackensack city.

On the east side of the Hackensack river, with the exception of a small area just north of the Paterson plank road, and near the Northern railroad, which is clay and peat mixed, it is all blue clay, very firm, and in some places over twenty-four feet deep.

The marsh bounded by the Morris canal, Hackensack river, Saw Mill creek, and the upland on the west, is diked in. This takes in most of the cedar swamps. All the rest of this tract of marsh is out to the tide.

Report on the Marsh on the Delaware, in Salem County.

The map of the marsh on the Delaware river and Salem, Alloways, Hope and Stowe creeks, represents the *nature* and *depth* of the surface material, the markings used being the same as those on the map of the Newark marshes.

The map shows that on Salem creek there is much more blue clay than peat. In many places the two are mixed, sometimes there will be a few feet of clay on the surface, while all under it is peat. This is the case on Fisher's Island, which has lately been diked in. On the surface is blue clay, about four feet deep, after this it is peat, and in many places over thirty-six feet deep. In some places on Salem creek soundings fifty feet in depth failed to strike bottom.

On the Delaware river, north of Salem creek, the clay and peat surfaces are in patches, the latter much exceeding the former in area. The marsh is not so deep as on Salem creek. On the Delaware river, between Elsinboro' Point and Alloways creek, the marsh is mostly peat, and varies from four to sixteen feet deep.

On Alloways creek the material is clay towards the head of the creek, and clay and peat mixed towards the mouth, and varying from eleven to thirty feet deep. On Stowe creek the material is mostly clay and peat mixed, in many places over thirty-seven feet deep. On Hope creek the material is either peat alone or peat mixed with clay, the depth varying between five and twenty feet.

It is exceedingly difficult to describe localities, on a plain like the marsh, on either of these maps. A reference to the figured depths, and the conventional markings on the maps, will give a clearer idea of their features and substance, than any description in words can possibly convey."

It should be observed that these maps, besides presenting a comparison between the marshes on the Delaware and those on Newark Bay, also furnish important information upon which to base plans for their reclamation, and by showing the material of which they are composed, they show the culture to which they are adapted, and the treatment they need to make them productive for general farm culture. It is an easy matter to make the blue clay deposits into the richest of farm lands as soon as they are well drained, but the peaty soils require much more skill and labor to bring them into the best state of cultivation.

The Wet Lands on the Passaic River and its Branches, the Rockaway and Whippany, above Little Falls.

The country inclosed between the Highland range of mountains, and the curved trap ridges called the First and Second Mountains, being a part of the counties of Somerset, Union, Morris and Essex, is not well drained. The Passaic river, with its branches, flows across the district in crooked channels and with sluggish current, and finally escapes from the basin by falling over a depression in the Second Mountain at Little Falls. The rocky substance of the Mount forms a natural dam, which effectually holds the river in check. So flat is the valley that in freshets the river, which is thus dammed, overflows its banks for more than twenty miles up the stream, and lay thousands of acres of land under water. The current i the river is so feeble that the freshets subside with extreme slowness, and it has frequently been the case tha the entire crop on these flowed lands has been lost, and th acumulation of stagnant water has caused fever and agu to become severe and wide-spread. The damages from spoiled crops, loss of labor, injury to stock, &c., could no have been less than $100.000 in 1867. The occupant of the land in this district have been contending wit this difficulty ever since the country was settled ; th channels of the streams have been cleared of obstructions ditches have been dug across the flat grounds, large expenditures of time and money have been made. But i has not been at all alleviated. It is to-day worse than i was fifty years ago.

The water power at Little Falls has been part used fo many years. A log on the reef, or a light wooden dam below which raised the water to near the level of th reef, has sufficed to turn the water off to the mill. During the present year a substantial stone dam has replace the former wooden one. The owners of the flowed land have always looked upon this dam with a jealous eye lest it might in some way increase the trouble the ree itself gave them.

The lack of drainage, and the losses attending it, ar apparent; the damage to public health is proved by th mournful experience of many, and the great importance t the State of having this beautiful valley fitted to receiv those who would delight to make it their home, if its salubrity were established, is becoming plainer every day. I view of these facts, and desiring to carry our work to prac

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tical ends, I have had levels run and soundings made along the Passaic from Little Falls to Chatham, and up the Rockaway and Whippany to the end of the flat grounds. The results of the survey are put down in the accompanying detailed map, profile and statement of distances, levels, and depths of water, as they were taken by Mr. Bowser. He says "the heights along the *surface* were found by leveling from the benches established by Geo. W. Howell, C. E., in 1868. The position of the *bottom* was determined by sounding in the channels of the rivers, and subtracting the depths from the heights of the surface. In the table the top of Beatty's Dam, at Little Falls, is the datum plane. The heights of the points both along the surface and the bottom of the river, are measured from this plane; those points which are below the level of the dam having a minus (—) sign before the numbers.

By an examination of this table, as well as by an inspection of the profile, it will be seen:

1st. That the bed of the Passaic. from Little Falls up to Horse Neck Bridge, which is $9\frac{65}{100}$ miles, is almost all below the level of the dam. Even in the dryest season the water in this part of the river must stand in many places eight, ten and even twelve feet deep, as there is no way for it to escape, except by evaporation, the bed of the river being so much below the level of the dam.

2nd. That the top of the reef 347 yards above the dam is twenty inches lower than the top of the dam; and the reef alone would dam the water nearly back to Horse Neck Bridge, making it six and eight feet deep in many places.

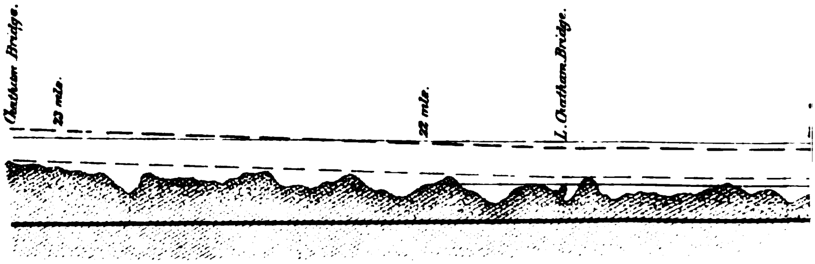
3rd. That the bar of boulders and earth at Two Bridges being but two-tenths of a foot below the top of the dam must be a great obstruction. Even if the dam and th trap reef were both taken away, this bar would dam th water back to Horse Neck Bridge, making it several fee deep. All the work of throwing trees and roots out o the river between Two Bridges and Horse Neck Bridge while these obstructions remain below, is so much tim and labor lost. One might as well throw trees and stone out of a mill-pond to make the water run, while there a good tight dam backing it up.

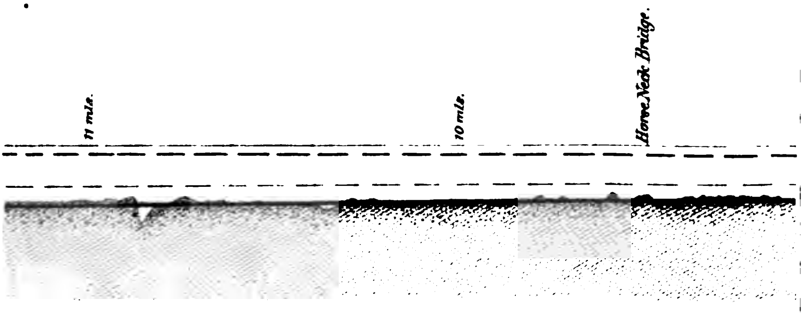
4th. That from the bed of the river at Lower Chatham Bridge to the top of Beatty's Dam, distant twenty-one and three-quarter miles, there is a fall of only $6\frac{3}{10}$ feet, o less than three and-a-half inches per mile. If this bottom slope from this bridge to the top of the dam were uniform, this fall would do very well for a large river lik the Mississippi, but for a small stream like the Passaic would give but a very sluggish current. A fall of thr and-a-half inches per mile will give the Mississippi, dow towards its mouth, a velocity of over six feet a secon whereas the same fall would not make the Passaic, abov Little Falls, run one foot a second.

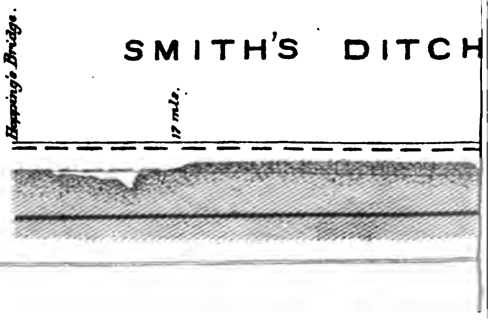
By applying the *New Formula* deduced by Captai Humphrey and Lieutenant Abbott in their investigation on the Mississippi—a formula applicable to the smalles streams and the largest rivers—by applying this formula t the Passaic, we find that a fall of seven and a half inches pe mile will give it a velocity between one and a half an two feet a second, even with the present very crooke channel. This fall can be obtained by cutting the dam down seven feet. The trap reef will have to be cut dow five and three-tenths feet. A small reef sixteen yard

Explanation of lines on the profiles, in the order of their succession.

– – – – –	*High water, Jan. 1. 1870.*
▬ ▬ ▬	*dto. in 1868.*
– - – - –	*Low water in 1868.*
– – – – –	*Grade line 7½ inch.s per mile.*
▬▬▬▬	*Level of Dam on Little Falls.*
▨	*Bed of the stream.*







above the dam will require lowering three and a half feet. From this point, up the river to Chatham, the present river bottom is low enough for the increased slope, with the exception of the bar at Two Bridges, and some insignificant bars at one or two other places; and the scouring action of the water, if the current were increased would probably soon regulate these.

A reference to the profile shows the new or proposed grade with a fall of seven and a half inches per mile—and it is seen that the present bed of the Whippany is above this, so that a small amount of work upon it would give a fall of from one and a half to two feet per mile, which will be sufficient to drain the adjacent lands as deep as is desirable." . . . . . .

There are many curious and interesting facts regarding this stream, and its deep channel, and the influence of obstructions in it—but it is not desirable to draw attention from the main point which is that *for any effective system of drainage for this valley the first step is to remove the obstructions at Little Falls.* Anything short of this will be incomplete, and temporary in its effect.

The advantages to be gained are very great. There are 11,400 acres in the townships of Caldwell, Livingston, Hanover and Chatham which are liable to be damaged by freshets, and there is an area of seventy-five square miles, or nearly 50,000 acres which is more or less affected by this insufficient drainage, and caused to be of questionable salubrity. It would be a small estimate to put an additional value of ten dollars an acre upon this whole valley on account of this improvement, if the land were to be used for farming purposes only, but when it is considered that the land is located within an hours ride of

New York City, and can be made most desirable for the homes of men doing business in the city, its additional value must be greatly increased. Neither does it follow, if this improvement is carried out that the water-power at Little Falls must be all destroyed; or the benefits which come from such an important manufacturing village be lost. Of the thirty-four feet fall, only the upper fourteen feet are used, and then but half of the water which flows in the stream. Under these circumstances it is surely possible to preserve the valuable mill-privileges of the Falls and yet make this needed improvement.

The valley of the Passaic above Chatham, is also suffering from obstructed drainage, and very great injury is being done both to agriculture and to public health in consequence. The Great Swamp in Morris and Passaic townships is almost a waste from the same cause—and like the others, its improvement would bring a large addition of taxable property to the state, and be of benefit to the community.

The people of Orange county, in New York, have made a vigorous attempt to remove the obstructions in the Wallkill, at the lower end of the Drowned Lands. The successful accomplishment of this work will be very beneficial to a large body of land owners in Sussex county, and it is to be hoped that it will be effectually carried out.

There is a much needed improvement of the same kind to be made in draining the Long Meadow on the Pequest, in Warren county.

The agricultural wealth of the State, as well as the health of our town and suburban districts, is so largely dependent on thorough drainage that it seems appropriate to copy here the conclusions upon this subject which were long since settled by the British Board of Health, and which are now everywhere accepted and are copied in all in all our books upon drainage.

The following are the chief agricultural advantages of land drainage to individual occupiers or owners:

"1. By removing that excess of moisture which prevents the permeation of the soil by air, and obstructs the free assimilation of nourishing matter by the plants.

"2. By facilitating the absorption of manure by the soil, and so diminishing its loss by surface evaporation and by being washed away during heavy rains.

"3. By preventing the lowering of the temperature and the chilling of the vegetation, diminishing the effect of solar warmth not on the surface merely, but at the depth occupied by the roots of plants.

"4. By removing obstructions to the free working of the land, arising from the surface being at certain times from excess of moisture, too soft to be worked upon, and liable to be poached by cattle.

"5. By preventing injuries to cattle or other stock, corresponding to the effects produced on human beings by marsh miasma, chills, and colds, inducing a general low state of health, and in extreme cases the rot or typhus.

"6. By diminishing damp at the foundations of houses, cattle sheds, and farm steadings, which causes their decay and dilapidation as well as discomfort and disease to inmates and cattle."

"The sanitary interests, also, of a locality urgently demand attention to the drainage of its land; for excess of moisture most powerfully influences the local climate, both as to dryness and temperature, as shown in the report of the Metropolitan Sanitary Commissioners, under the following heads:

"1. Excess of moisture, even on lands not evidently wet, is a cause of fogs and damps.

"2. Dampness serves as the medium of conveyance for any decomposing matter that may be evolved, and adds to the injurious effects of such matter in the air; in other words, the excess of moisture may be said to increase or aggravate atmospheric impurity.

"3. The evaporation of the surplus moisture lowers temperature, produces chills, and creates or aggravates the sudden and injurious changes or fluctuations of temperature, by which health is injured.

"NOTE.—A farmer being asked the effect on temperature of some new drainage works, replied that all he knew was, that before the drainage he could never go out at night without a great-coat, and that now he could, so that he considered it made the difference of a great-coat to him."

The outlet for drainage water is a most essential part of any system of works, and being generally outside the lands to be drained, is a matter of difficult adjustment, in apportioning its expense. The difficulties, however, should not hinder their being made, for, quoting again from the same authority: "Whatever amount of money may be spent for relief by drainage, or however skillfully drainage works may be constructed, the money and the labor will be thrown away, unless the natural outfall be kept clear, or unless an appropriate artificial outfall be provided and kept open."

I would respectfully suggest to this Board that their influence could be usefully exerted in procuring such legislation as would make these improvements effectually, and without being burdensome.

III. ON THE SOILS OF THE STATE, &C.

A beginning has been made upon this subject. A large collection of soils from different parts of the State has already been selected. It is, however, only the beginning of what is needed. By continuing to collect, analyse, and describe soils, we shall finally get together material which will make a classification of our soils possible, and enable us to present principles which must influence the practice of tillage. The soils have a general resemblance in composition, to the rocks which underlie them, and as the rocks extend in belts, across the State from northeast to southwest, the various classes of soils must also lie in the same way. And if a whole belt of soil has the same general character and composition, it necessarily follows that all parts of it are adapted to the same management, and that the same principles of tillage and fertilization should be used throughout the whole. When general principles like these can be established and brought to the knowledge of the great body of farmers, then their united efforts will be intelligently directed, and the methods of a sound practice regulated and put in operation. There has heretofore been little profit derived from the analysis of soils, but it does not follow that it must be so in the future. There has been a lack of scientific knowledge, to rightly interpret the results of analysis, but this will be met when the attention of whole communities is drawn to the same points.

An application of these statements may be seen in the soils of the valleys in which *magnesian limestone* is the underlying rock. Soils and subsoils to the number of twenty specimens have been selected from various parts of these valleys in Sussex and Warren, and in Pennsylvania from the New Jersey boundary southwest to Lebanon. The following table gives in the first column the average of ten soils, and in the second column the average of ten subsoils.

Analyses.

Silica	67.88	65.31
Per-oxide of iron,	4.57	8.11
Alumina,	12.88	13.10
Oxide of Manganese,	.44	.37
Lime,	.96	.59
Magnesia,	1.47	1.34
Potash,	2.90	3.87
Soda,	.43	.69
Phosphoric Acid,	.78	.80
Sulphuric acid,	.03	.04
Organic Matter,	6.61	3.72
Water,	1.61	1.70
	100.56	99.64

These soils have been noted for their fertility, and have been cultivated ever since the first settlement of the country. They are specially adapted to the growth of wheat, and have always yielded good crops even under the worst of management. The analysis shows that they contain an abundance of all the essential elements of fertile soils; the phosphoric acid, potash, lime, magnesia, and sulphuric acid. The practice of farmers is to enrich these soils by the addition of lime, and by raising clover.

It is not thought profitable to keep any stock upon it except sufficient teams to do the work. Plans to increase the supplies of barn-yard manure, like those pursued in less favored soils, are not thought necessary. Lime causes the mineral ingredients to become soluble, and clover supplies the elements of ammonia. With analyses like these, the intelligent farmer is prepared to lay out his plans for farm management. He knows that he need not buy manure; his attention must be directed to the best tillage and cropping to bring out what is already in the soil.

IV. IRON ORES.

The mining of magnetic iron ore is carried on to about the same extent as in former years, and there is a reasonable prospect that the rich mines now worked will continue to meet the large drafts made upon them for many years to come. The demand for ores is large, and the stimulus to renewed efforts after new mines is great. The veins which were discovered two or three years ago, near Chester, Morris county, are still being worked, and further explorations made, with encouraging results.

The annual supply of magnetic iron ore from the mines could be largely increased, if there were some cheap and easy mode of removing sulphur from the ores. There are many veins and parts of veins of ore which contain a small percentage of sulphur, and for this reason are considered worthless. The common method of roasting sulphurous ores drives off a very little sulphur, but not enough to make the very large quantity of ore now in rejected mines suitable for the forge or furnace. Mr. A. S. Hewitt's Exposition Report *On the Production of Iron and Steel* states that "In the preparation of ore for the blast furnace, Sweden exhibits the model of a roasting furnace invented by Mr. E. Westman, and which was adopted, in the first place, at Dannemora works, and since generally introduced at the other iron works in Sweden. It consists of a vertical furnace, which is heated by a portion of the gas drawn from the blast furnaces themselves, and introduced at the bottom of the roasting furnace through suitable flues, by the aid of natural draught. The temperature in the furnace is carried to such a degree as to soften the ore, and drive off the sulphuric acid arising from the oxidation of a portion of the sulphur, disengaged, by a distillation of a lower temperature, from the pyrites which may be mixed with the ore; a portion, moreover, of the sulphur is oxidized by the oxygen of the ore. Ore thus roasted, however dense when charged into the roasting furnace, is discharged at the bottom quite porous, like a sponge, and almost entirely free from sulphur, if it do not contain more than four per cent. in its natural state. With ore so roasted, and which presents an entirely different appearance from ore prepared in a common kiln, the statement is not surprising that the blast furnace runs with far greater regularity, and with much less consumption of fuel. The introduction of this roasting furnace will be of great value when magnetic ores are smelted with charcoal. It is highly probable that even in furnaces fed by mineral coal, it will bring into economic use a great variety of ore now rejected on account of its sulphur. So important did this furnace appear, that the writer at once engaged a Swedish engineer to proceed to America, and erect a furnace at Ringwood, in New Jersey. The furnace was built and tried, and its performance is more than equal to the promise. It can be examined by the public at any time.

"Besides economizing coal, the Westman furnace, in connection with other improvements resulting from a more accurate knowledge of the theory of the blast furnace, and a careful study of its operation, has greatly increased the weekly product of the charcoal furnaces in Sweden. The general dimensions of the blast furnaces are from eight to nine feet across the boshes, and from forty to fifty feet in height. The average product of these furnaces, driven with a blast heated to 150° or 200° centigrade, is about seventy-five tons per week, which is nearly double the product made a few years since, and now made in the United States from the same class of magnetic ores, which must be carefully distinguished from the brown hematites of Connecticut and the per-oxides of Lake Superior. The charging of the furnace, in particular, is most carefully attended to; absolute uniformity in the size of the pieces of ore is insisted upon, and the charge is distributed over the furnace by a shovel, in which it is first weighed, and then run on a suspended railway to the tunnel head of the furnace, which is never closed. The most intelligent engineers expressed the opinion that the furnaces would give better results if made larger; but as they are, 100 pounds of cast iron are produced with ninety pounds of charcoal, which is as near as possible at the rate of 112 bushels to the ton."

The introduction of improvements like these, in our iron works, would bring into use thousands of tons of ore that are now considered worthless. It would also increase the manufacture of charcoal iron, which is so necessary for the production of the best qualities of steel. The charcoal blast furnaces now in common use require 200 bushels of charcoal for each ton of iron made from magnetic ore.

Hematite ores have been much sought after in our State, for the purpose of mixing with the richer magnetic ores, mixed ores working much more freely in the blast furnace than the magnetic ores alone. A large amount of these ores is taken from various localities in the valleys where magnesian limestone is found, for the Pennsylvania blast furnaces. This limestone occurs in great abundance in New Jersey. All the limestone valleys southeast of the Blue mountain, in Sussex and Warren counties, are underlaid by this variety of rock Heretofore very little hematite has been found in the State. The Edsall and Pochuck mines, near Hamburg, have been the most productive, and some small workings have been carried on at various places along the Musconetcong and Pohatcong creeks. In the summer of 1868 a deposit of hematite was found on the farm of Thomas Shields, near Beattystown, Warren county. Some of the ore was taken out, tried, and found to be of good quality. During the present season about eight hundred tons of the ore have been sent to market; trial pits have been sunk over an area of several acres, ore was found in all of them, and a steam engine and appliances for raising and washing the ore have been put up on the ground. The workings show a large body of good ore, and there is no question that this mine will yield an abundant supply for many years to come.

The success which has attended this enterprise has encouraged others in these valleys to search for similar ore, and there is a reasonable prospect of its being found, in many places. The search for this ore should be limited to the limestone valleys. It is not magnetic and the compass cannot be used in searching for it. Its surface indications are found in little fragments of the ore scattered on and through the soil, and in an occasional boulder of the ore. The *final proof* of ore being in any place, is, of course, by digging down through the earth until the ore, or solid rock is found. No blasting of rock is needed. Leslie, in his Iron Manufacturers' Guide; p. 570, says: "Among the circumstances which usually indicate an abundance of the limestone ore beneath the soil, it should be mentioned that one of the most essential is a considerable thickness in the deposit of ferruginous loam, clay, or other earthy matter, resting on the strata. This will, of course, be marked by a corresponding evenness of the surface; for when the beds of limestone are naked of soil in many places, the covering of earth, which must contain the ore, can nowhere be deep. Another very necessary condition is, that the earth overlying the rocks should have a large amount of oxide of iron diffused in it. This will show itself by a characteristic bright yellow or clear brown color. It must be observed, however, that the existence of a large quantity of oxide of iron in the deeper part of the soil will very frequently not be perceptible in the color of the surface of the ground—the ore being confined to the lower portions of the mass—so that much good ore-ground is often neglected from want of perseverance in digging."

The search for ores of this kind must necessarily be the work of individual enterprise, but the laboratory of the survey is open for the testing and examination of samples for their benefit, and the members of the survey are ready to give any information they may be able, to facilitate the search. Those wishing specimens examined are invited to send them to the office of the Geological Survey at New Brunswick; with as full an account as possible of them and their location.

V. FIRE AND POTTERS' CLAYS.

The rich deposits of Fire Clay at Woodbridge, South Amboy and Trenton, are gradually growing in reputation. They are purer and richer than the foreign clays, yet they have been sold at less than a quarter of the price which those bring. They stand fire better than any imported clays, yet fire clays and fire bricks are brought in and sold at prices far above those asked for our own. There are differences in the modes of working different clays, and it is probably owing to the want of skill in managing ours that has kept them from being estimated at their true value. Heretofore all the clay used in making the melting pots for glass-houses, was brought, either from Europe, or from the vicinity of St. Louis, in Missouri. Nearly two years ago, at the request of Wm. B. Dixon, of Woodbridge, we called the attention of several glass manufacturers to the excellent qualities of these clays, urging that they would answer for the glass-house pots and furnaces, when properly worked, and that a great saving could be effected by using them. A letter has lately been received from Whitall, Tatum & Co., of the Phœnix Glass Works at Millville, in which they say they have been using Mr. Dixon's Woodbridge clay, more or less, for about two years, "in furnace work and in pots for making glass. It appears to us, after this trial, fully equal to Missouri or German clay, and we think this discovery will lead to sales of $50,000 a year of this clay, instead of importations from Germany or England, or freighting from Missouri."

This result is a source of great satisfaction to me, for these fine clays have heretofore been wasted on objects which could just as well have been made from inferior clays, and the most accessible localities were being exhausted before the rare qualities of the material were at all understood. It is to be hoped that our manufacturers will soon bring the requisite skill and intelligence to bear in turning these clays to the best account.

Clay suitable for porcelain, fine and common pottery, paper facing, alum, fire brick, glass-pots, crucibles, stone ware, sewer pipes, &c., can be found in any quantity; and the poorer clay makes the strongest brick and drain pipe that come into market. The belt of country in which these materials is deposited, is admirably located for a great business, and the potteries, fire brick factories, &c., at Trenton, Woodbridge and Amboy show only a fraction of what this business will be in a few years.

With compliments of

JAN 17 1930

Geo. H. Cook

ANNUAL REPORT

7960

OF THE

STATE GEOLOGIST

OF

NEW JERSEY,

FOR THE YEAR 1870.

NEW BRUNSWICK:
NEWARK DAILY ADVERTISER PRINT.
1871.

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GEOLOGICAL SURVEY OF NEW JERSEY.

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STATE GEOLOGIST.

GEO. H. COOK, New Brunswick.

To His Excellency Theodore F. Randolph Governor of the State of New Jersey, and ex-officio President of the Board of Managers of the State Geological Survey.

Dear Sir:—I have the honor herewith to submit my annual report, on the Geological Survey of the State, for the year 1870.

With high respect,

Your obedient servant,

GEO. H. COOK,
State Geologist.

Rutgers College,
New Brunswick, Dec. 31, 1870.

REPORT.

During the year which has just closed:

Edwin H. Bogardus, the chemist of the Survey, has been fully occupied with the analysis of soils, ores and marls, and other fertilizers. His work has extended through the whole year.

Prof. Edward A. Bowser, Civil Engineer, has surveyed the Passaic River from Millington to Chatham, and the Pequest River through the Great Meadows, and has prepared profiles and maps of them. He was employed only a part of the year.

In accordance with a plan submitted to the Board of Managers and approved by them, I have spent between four and five months of the last year in a visit to the Drained Lands of England and Holland, in examining some of the most noted of the Swedish, German and English Iron Mines, and in studying the condition of Agriculture in the different countries visited.

PUBLICATIONS OF THE SURVEY.

There is a continued inquiry for the results of the Survey as published in the Geology of New Jersey. Copies of the work have been deposited in all the public libraries of the State and in those of the cities and towns adjoining. A list of libraries in which it can be found, was published in last year's Report of the Survey.

Both the book and maps are sold to any who wish to purchase at the mere cost of paper, printing and binding. A descriptive list of the publications and their prices and places of sale will be found in appendix C.

PROGRESS OF THE WORK.

In the last annual report it was stated that the chief operations of the Survey would be directed to putting the results of the work in form for practical use. And that in carrying out this leading idea the investigations and conclusions would be arranged and published under the following general heads:

1. On Fertilizers found in the State, and the means of making them more quickly and generally useful.
2. On the Marshes and Tracts of land subject to protracted Freshets.
3. On the soils of the State, their origin, chemical and physical properties, and distribution, with suggestions for their most productive management.
4. On the Iron and Zinc Ores of New Jersey.
5. Additions to the Scientific and Economic Geology of the State.

Upon each of these topics materials have been collected, and progress has been made in preparing them for publication.

I.

On Fertilizers found in the State, and the Means of making them more quickly and generally useful.

In the last report, Analyses of Marls, from the largest marl diggings in the State were presented and an attempt was made to establish the principles for their valuation. Tables were given to show the prices of the different fertilizing constituents of the marl, with which by a very simple calculation the value of each specimen could be determined. The results obtained in this way were interesting, and, as I think, relatively correct, though of course not entirely convincing to some of the dealers in this very useful substance. But I consider the matter to be of too much public importance to leave it without further inquiry, and have therefore had carefully averaged samples taken from the pits of the several companies which deal in marl, and herewith present the results.

ANALYSES.

	1	2	3	4	5	6	7	8
Phosphoric Acid..	1.47	1.60	1.28	2.46	1.34	3.17	4.67	1.14
Sulphuric Acid...	0.00	0.00	1.37	0.17	0.00	0.25	0.51	0.14
Silicic Acid......	50.85	51.10	51.92	57.35	46.82	59.05	52.70	38.70
Carbonic Acid....	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.13
Potash...........	5.33	6.46	5.36	4.47	5.59	4.72	3.81	3.65
Lime.............	1.65	2.13	1.68	3.36	2.02	4.65	5.52	9.07
Magnesia.........	2.95	3.85	3.38	2.99	3.10	2.66	2.70	1.50
Alumina.	6.89	9.15	5.40	5.86	6.48	6.67	8.66	10.20
Oxide of Iron....	21.34	18.20	19.82	15.03	23.93	11.27	15.92	18.63
Water...........	8.40	6.75	8.70	8.20	9.70	7.50	6.40	10.00
	98.88	99.24	98.91	99.89	98.98	99.94	100.89	99.16

1. Marl from the pits of Dickinson Brothers, Woodstown.
2. " " " " West Jersey Marl Co., Barnsboro.
3. " " " " Pemberton Marl Co., Pemberton.
4. " " " " Vincentown Marl Co., Vincentown.
5. " " " " Cream Ridge Marl Co., Hornerstown.
6. " " " " Squankum Marl Co., Farmingdale.
7. " " " " Squankum & Freehold Marl Co., Farmingdale.
8. " " " " at Marlboro, Mon. Co.

To compute the value of these marls the prices of different commercial manures, as given by our best authorities, were presented in full. I here present them again only changing that of Prof. S. W. Johnson, and substituting in its place the prices he gave in his report "On Commercial Fertilizers," made to the Connecticut Board of Agriculture, in June, 1870. I reprint also my reasons for the prices I assume for the potash and phosphoric acid in the marl.

Tables for Calculating the Value of Greensand Marl, and for Comparing it with other Fertilizers.

TABLE I.

Stockhardt's Table of the gold values of the chief elements in fertilizers, copied from Caldwell's Agricultural Chemical Analysis.

Form in which the substance exists in the fertilizer.	*price per lb. in gold.*
Phosphoric Acid, soluble in water as in super-phosphate,	$ .12½
Phosphoric Acid in Peruvian Guano, ...	.10
Phosphoric Acid in steamed bones finely ground, in rape cake, poudrette, etc., ...	.08¼
Phosphoric Acid in Baker guano, ...	.07½
Phosphoric Acid in coarse bone-meal, fresh human urine, etc., ...	.07
Phosphoric Acid in coarse broken bones, fresh human excrements, stable manure, etc., ...	.05½
Potash as potassic sulphate, ...	.06½
Potash as potassic chloride and in other forms, . .	.05½
Nitrogen easily soluble, or in compounds that are readily decomposed, as in ammonia nitrate, dried blood, meat, urea, etc., ...	.22
Nitrogen in finest bone-meal, poudrette, etc., . . .	.19½
Nitrogen in coarse bone-meal, rape meal, horn-meal, wood-dust, fresh human urine, ...	.16½
Nitrogen in coarse broken bones, horn shavings, woolen rags, fresh human excrements, stable manure, etc., .	.13¾

TABLE II.

The English valuation of these substances is given in Vol. 20, p. 74, of the *Country Gentleman*, by Dr. Voelcker, Consulting Chemist to the Royal Agricultural Society of England. It is as follows, allowing two cents for each English penny:

1. Nitrogen in the form of ammonia, . .	16	cts. per lb.
2. Nitrogen in animal or vegetable substances, .	12	"
3. Nitrate of Soda, ...	4	"
4. Phosphate of Lime, (bone earth), . .	2	"
or Phosphoric Acid alone, . . .	4	"
5. Soluble Phosphate of Lime, or Bi-Phosphate of Lime, ...	9	"
6. Salts of Potash, ...	2½	"
7. Gypsum, ...	2	cts. per 10 lb.
8. Lime, ...	2	" 12 "
9. Carbonate of Lime, ...	2	" 25 "
10. Magnesia, ...	2	" 10 "
11. Organic matter, (humus), . . .	2	" 20 "
12. Common Salt, ...	2	" 10 "

PRICES FROM PROF. S. W. JOHNSON.

Prof. S. W. Johnson, of the Sheffield Scientific School, New Haven, has given a new table of prices for some of the most important manures, in a Report on Commercial Fertilizers, made to the Connecticut Board of Agriculture in June, 1870. It has been deduced from the prices of various chemical fertilizers, after a careful re-examination of the whole subject; and is as follows:

Potash, ...	7	cents	per lb.,	currency.
Nitrogen,*	30	"	"	"
Soluble Phosphoric Acid, .	10¼	"	"	"
Insoluble Phosphoric Acid, .	6	"	"	"

The phosphoric acid in the marl is combined mostly with lime, though a little of it is probably combined with oxide of iron. The phosphates of lime and iron are both in very fine powder, or else in soft grains, so that while they cannot be quite as soluble as super-phosphate, they are much more soluble than any bone-dust. Judging from Stockhart's table of prices and qualities of fertilizers, I think the phosphoric acid in our marl should be rated between that in guano, which is 10 cents a pound, and that in steamed bones, which is 8¼ cents, and therefore propose for it in our calculations, 9 *cents as the price per pound.* The potash in the marls is combined with silicic acid, forming silicate of potash, which is not readily soluble in water. Johnson's price, 7 cents a pound, is for soluble potash as it is found in carbonate of potash (pearl-ash,) sulphate of potash, muriate of potash (chloride of potassium,) or crude potash. The potash in the marls, is only dissolved out slowly by the action of water containing carbonic acid, and so becomes available. Until there is some more decided reason for fixing a different price, I will set down its value at 2 cents a pound.

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*Ammonia is $\frac{14}{17}$ Nitrogen, and according to the above price for Nitrogen, Ammonia should be worth a little under 25 cents a pound.

The value of the several marls given in the above table would then be easily made. Considering the phosphoric acid and potash as the only parts of the marl worth transportation, their values range from $3.50 to $8.50 a ton ; and I believe, that in comparison with the prices paid for concentrated manures, they are worth that price to the farmer. The cost must be taken when they are upon the soil, and not, as might be thought, when in store. I am confirmed in my opinion of their value by the testimony of successful farmers, who have used them for twenty years or more ; and who assure me, they can better afford to incur an expense from $5 to $8 a ton, than to farm without them or to use any other purchased fertilizers ; and also confirmed by my own observations in all parts of New Jersey where marl has been used. It gives lasting fertility to the soil. While all other fertilizers are exhausted and the soils become poor, I have never seen a field which has once been well marled that is now poor. One instance was found where poor and sandy land was marled more than thirty years ago, and has ever since been tilled without manure, and not well managed, which is still in good condition. Occasionally marled fields are seen that do not grow crops as large as they once did, but all their fertility is immediately restored by a dressing of lime; an effect which could not have been produced by the lime on unmarled land.

The principle of computing the value of manures in this way, is a correct one, and is accepted everywhere. The prices depend upon the benefits received from the use of the different fertilizers; those benefits being ascertained by the experiments of different persons continued for a number of years. Of course such prices are not yet very accurately settled, and further experience may materially alter some of them. It is very desirable that the attention of observers should be directed to this subject, and if changes can properly be made in the prices, that they be made, and reasons given therefor. I am in the frequent receipt of inquiries as to the value of marl from different pits. In answer to those inquiries I would refer to the analyses and to these lists of prices, and ask the inquirers to compute the value of the marls from them—and if from trial they find reason to modify the prices, it will be esteemed a favor to have them send their conclusions, with the reasons for them, to the office of the Geological Survey.

Other investigations are in progress upon our natural fertilizers, and the subject will be taken up and discussed at length in a future report.

II.

On Marshes and Tracts of Land subject to Protracted Freshets.

In the last Annual Report a survey and profiles were given of the Passaic, Rockaway and Whippany Rivers, in Morris, Essex and Passaic counties. It comprised that portion of the streams about their junction and extended from thence downwards to Little Falls, and up the Passaic to Lower Chatham Bridge, up the Rockaway to the Parsippany turnpike Bridge, and up the Whippany to the village of that name.

There is a large area of land on the borders of these streams which is subject to long continued overflow; and on which in some seasons the crops are entirely spoiled by the water. The object of these profiles and maps was to show the real condition of the streams and to furnish data upon which to base plans for making them fulfil their proper functions in draining the country through which they find their way. The natural obstruction to the flow of water, in these streams is found in a ledge of rocks at Little Falls. This obstruction has been increased by the erection of a dam just below the reef which is raised a foot and a half higher than the reef itself.

The bed of these rivers is deep for the amount of water to be carried, but the current is very sluggish on account of its slight descent. In fact, for nearly eighteen miles up the Passaic from Little Falls, the bottom of the stream is lower than the dam, so that all the current there is comes from the piling up of the water along the more remote parts of the stream and so making an inclined surface down which the water can make its way by this force from behind, instead of being moved by the ordinary power of gravity.

To prevent the overflow of these streams it is necessary to increase the quickness of their currents, and so to enable them to carry within their banks, all the drainage water ot the country.

By the profiles it was shown that the form of the rocky reef at Little Falls was such as to admit of its being lowered five and a half-feet at a very moderate expense; and that any further lowering could only be effected by an enormously increased expense. It was remarkable too, that if the rock were lowered to that amount, a grade line with a descent of seven and a half inches per mile would fit the natural bottom of the stream as well as the rock when thus cut down, and that the slope would be almost uniform from lower Chatham Bridge to the Dam. Only a few and comparatively insignificant bars of boulders, gravel, sand and mud would have to be opened to render the descent regular.

The descent in the Whippany can be made somewhat greater, as it should be on account of its smaller size. The expense attending these improvements is not great, and could very easily be met by the owners of the land to be benefitted.

The dam and the water power originally obtained from the reef itself, present more serious dificulties, and become the causes of the heaviest expenses in carying them out. But an examination of the reasons which call for the improved drainage will show that it must be made, and it should be begun at once.

The damage done by freshets in a single year, has more than once been enough to pay all the reasonable expenses ot this improvement. There are 11,400 acres liable to overflow; most of these are in meadow and in favorable seasons yield valuable crops of hay. When this hay is spoiled the owners lose it and the labor they have provided to gather it, so that it is not extravagant to estimate the total loss at $100,000, and some consider it to be much more. And this loss has occurred a number of times and sometimes two years in succession. The occurrence of such freshets, and so much stagnant or sluggish water renders the whole region unhealthy, and fever and ague prevail to a great extent in some years.

The thorough drainage of these valleys would render the whole district more healthy and would greatly increase the productiveness and value of the land. In addition to these great advantages to the residents and land owners, the improvement is of general importance to the State, and it would render one of its most lovely valleys attractive and desirable as a location for the country homes of those who do business in our great cities. It is to be hoped that this important work will be begun soon and carried forward with prudence to completion.

During the past season the Survey has been continued up the Passaic from Chatham to Millington and also up a short branch of the Passaic, called Dead River.

There is a fall of twenty feet in the Passaic within about three miles of Chatham, and there are four mills upon it, each of which has a dam. The upper of these is so high that the water is checked in its current for twelve or more miles up the stream, and the low lands along its borders are laid under water with every large rainfall. The meadows are not so extensive as they are upon the same stream below Chatham, but what there are are rendered almost worthless by the frequent floods.

The greatest injury however, is to the health of the residents and the attendant disrepute of property which would otherwise be amongst the most desirable in the State. For the condition of the stream, location and extent of its obstructions, and the obvious means of overcoming or removing them, a careful survey of the stream has been made by Mr. Bowser and his report and profiles are herewith presented. (See appendix A.)

The great meadows in Warren County, have also been Surveyed during the past season. These meadows occupy almost the whole of one of those beautiful subordinate depressions of the great Kittatinny Valley. They lie upon both sides of the Pequest River, in the townships of Independence and Hope, and extend from Danville in Warren to Tranquillity in the borders of Sussex County, a distance of eight and a half miles in a strait line; and they have for a considerable portion of this distance, a width of one and a half miles. They cover an area of fifty-five hundred acres. The soil in these meadows is a black and peaty earth, full of water, and liable to frequent overflows from the sudden rise of the Pequest. It is too flat and wet to be cultivated, and the greater part of it produces only wild and and sour grass of but little value. A part of it along the stream is swampy and covered with heavy timber.

The right of soil in these meadows is held at a very low price, but if properly drained they would become both valuable and productive, and an ornament to the country, instead of being as they now are, an unnecessary blur upon its surface. The original cause for this flat tract of country is found in two reefs of rock which cross the Pequest near Vienna. Projects for draining and improving these meadows have frequently been discussed, and some of them begun, but nothing has been carried through. It has been questioned whether it would be most effectual to remove the obstructions in the stream and leave it to pursue its present channel, or to make a new cut from the river at the lower end of the meadows in a nearly direct line across the ridge back of Danville Church, and on to join the old bed again about a half mile below. Levels and measurements have been taken on both these lines by Prof. Bowser, and his report and maps are herewith submitted. (See appendix B.)

In regard to all these improvements, it should be observed that their completion will require considerable time, some of them several years, if they are to be done effectually and with a due regard to economy. The first object to be secured is a good and sufficient outlet. The work must in all cases begin at the lowest point; and when that is made free and clear, the next point of obstruction up the stream should be removed or opened, and so on in succession. By this means the current is increased from the first, and made to assist in cutting away the soft bars and other obstructions of recent origin. The depth of water is diminished and the labor and expense of working in it is made lighter. In a few years, by pursuing this course, the work can be done so as to secure full and permanent benefit to the whole district needing drainage, and to the State. Any other plan will be expensive and wasteful, and will need to be gone over again; and in the end the method given in these reports must be carried out.

ON MARSHES AND RECLAIMED LANDS.

In former reports reference has been made to our tide marshes and the importance of reclaiming them. In the report of 1869 there were two maps of marshes—one of that about the head of Newark Bay and the mouths of the Passaic and Hackensack Rivers, and the other of those along Salem Creek and the head of Delaware Bay. In these maps the outlines of the marshes were shown, the character of their soils, whether peat, clay, or sand, and their depth to solid ground. The means which have been used for their improvement in Salem and other Southern counties were described, and the extraordinary fertility of the soil upon them was shown at length. The beginning of work for reclaiming the marsh between the Passaic and Hackensack Rivers, near the head of Newark Bay, was also reported. This latter work is progressing; the tide water appears to be effectually shut out, a large tract of land has been plowed, some portion has been cropped, and the enterprise of bringing it into cultivation bids fair to be a success.

The large extent of marshes and salt meadows in our State still unimproved makes this subject one of much interest to the people. And the amount of work to be done and of capital to be invested renders it very important to have the fullest information in regard to what has already been learned by experience in other countries in reclaiming similar lands. To learn more of such works, I have made a visit to the drained lands of England and Holland, and present the following report upon them.

In England the largest drainage works are in what is called the Fen-country. This is an extensive tract of wet, swampy, and marshy land lying on the east coast, beginning about eighty miles north of London, in the counties of Norfolk, Cambridge, and Lincoln, and near the mouths of the Rivers Ouse, Nene, Witham, and others. There are a number of tracts along the east coast, and some of large extent, but they all have the same character and their management is similar. The drainage of the Fen-county about the Nene and Ouse was first undertaken by the Duke of Bedford, and hence is known as the Bedford Level. It comprises about three hundred thousand acres. Much of this land lies below high water level, and so was liable to the overflow of the tides; but its greatest damage was from floods in the rivers which pursue their crooked and sluggish courses through it. These streams carried the drainage water from as much as five thousand square miles of the higher country, and in heavy rains or in wet seasons they overflowed their banks and laid the whole of this flat country under water. In dry seasons some of the land could be cultivated and summer crops secured, but in wet seasons all crops were destroyed. From the earliest periods of English history, attempts were made to prevent the damaging effects of these overflows, but for a long time with only indifferent success. The leading features of the plan pursued by the Earl and Duke of Bedford in their works between 1630 and 1653 were to convey the upland waters through the level to the sea by means of straightened and embanked rivers, and to prevent the tide from entering and overflowing any portion of the Level. The Level was divided into three parts; the North Level containing 40,000 acres, the Middle Level 140,000 acres, and the South Level 120,000 acres. Each level was defended by high barrier banks.

Another feature in his scheme was to cut large new straight drains within each level to carry the ordinary rainfall to the rivers into which they could be discharged by sluices.

The two great defects of this plan were—first, the omission to provide for the improvement of the natural outlets to sea at Lynn and Wisbeach. It went no further than getting the water out of the Fens into the drains and rivers running through the Level, and gave no attention to the discharge therefrom; whereas its first great work should have been to secure for these drains and rivers the best outlet possible to sea, for without that all internal works, however good, must eventually fail. The second defect was in not making the new drains and cuts of sufficient depth. They did not understand or properly consider the nature of the soil to be excavated. This soil was a deep bed of peaty earth which had been growing and accumulating for centuries, and for drains to be permanently efficient, it was necessary that this bed should be cut quite through to the natural soil on which it rested. This was not done, and the consequence was the peat bottoms of the drains began slowly to rise up towards the surface of the water, and so to impair and finally ruin them. While this was going on, a process of a directly opposite character was going on in the drained lands around. While one was rising the other was subsiding. This soon made it necessary to provide other means for passing the drainage water from the lands into rivers and large drains. Associations of neighboring farmers were formed for more effectually draining small districts, and these associations partially attained their objects by erecting scoop-wheels for lifting the water, and wind-mills to drive them. These were in a measure successful, but not to the degree that was needed. In 1821, after years of opposition, a deep cut was made to shorten the course of the River Ouse near Lynn. At this place the river took a bend almost at right angles to its general course for a length of five and a half miles, forming almost a semi-circle, while the diameter joining its two ends was only two and three-quarter miles across. The substitution of this straight cut for the former long and tortuous one was attended with most remarkable and beneficial results. The Ouse at the upper end of the cut had its low water line reduced seven and one-half feet, and there was a corresponding lowering of the water surface in all the connecting drains. Various internal improvements were carried out at the same time, to secure the full benefit of this lower outlet, and steam was substituted for the irregular and uncertain force of wind.

Since then an Estuary Cut for two miles below Lynn has still further straightened the outlet of the Ouse to the sea, and has caused a depression of the low water mark at Lynn of from three to four feet, and has given a greatly increased efficiency to drainage by sluices. It has also diminished the lift for the water which has to be raised from the ditches into the drains and rivers. The system of works necessary to keep up this drainage has been planned by some of the best English engineers, and the constant attention of several professional engineers is now required to keep the various parts in working order, and to make such new erections or changes as are needed. But it is a marvelous success, and the country which was formerly a worthless marsh is now the most productive land in England.

To Mr. Alfred S. Ruston, of Chatteris, England, I am indebted for many particulars relating to the fens. He went with me to examine various farms, to explain their modes of culture and the system of drainage which is now in operation. He gave me all the particulars I could ask for, in full detail, and I cannot do better than use his own words in presenting them :—

"If fen-lands are to be perfectly and successfully drained, the true principle is first of all to secure the best possible outfall for the discharge of the waters, and then to construct the internal works of corresponding dimensions and depths, giving where practicable a natural drainage, and where not, reducing the pumping power to a minimum; and sooner or later I conceive this will be the principle adopted by all the drainage levels in the kingdom.

"One important and somewhat startling fact in connection with the review of the drainage history of the great level during the last two or three centuries strikes one, and that is, that all the great works which have contributed to drain the land effectually, rescuing it from all risk of winter floods, and making it really valuable, have been made during the present century. At the beginning of the century the lands were little more than summer lands, and men were considered demented who ventured to sow a whole field with wheat. But now the fens are the great corn-producing lands of the kingdom, and have been not inaptly termed 'the granary of England.'

"The subsidences of Fen lands after they become drained is a subject deserving attention. The more we drain the lower our lands become, and we are beginning to enquire what is to be the end of all this. I am informed by Mr. Lawrence, the agent to Mr. Wells, that when Whittlesea Mere was drained, to ascertain accurately what the subsidence was, a Doric column was placed in the ground, on which feet and inches were marked downward from the capital, which was the original surface of the land. That surface is now seven feet below what it was when they began to drain the mere eighteen years ago; and in the middle level on all our old drained lands we find the subsidence is still going on at the rate of an inch per year. We learn this from our drainage engines, which are continually requiring the centres of their water wheels to be lowered, or the ladles to be lengthened or they would soon lose their dip altogether. The increased facilities of discharge through the improved out falls must continue to be felt until the peaty subsoil shall well nigh disappear. One of Lord Orford's companions on referring to their passage through Salter's Lode Sluice, tells us that the tide rises at that place five or six feet. On the 21st of February of the present year, it rose to twenty-two feet three inches at 11:15 P. M. The effects upon drainage of this altered state of things, and consequently upon subsidence, must be obvious to everyone.

"The Fen rivers and drains so useful and essential for the discharge of the flood waters of winter are scarcely less valuable for the supply of fresh water in the summer. It is not easy to overestimate the immense value of a good and a liberal supply of fresh water for the whole Fen County during the dry summer months, and I need hardly say every effort is made to obtain this. The practice of irrigation has not found much favor in the Fens, and it is questionable whether it would be of any great good where the waters possess so few fertilizing elements. Irrigation appears to depend for its success very much upon the chemical substance contained in the waters. An analysis of the water will pretty correctly indicate what will be the effects of its overflow Cultivation and drainage have gone on hand in hand, each successive improvement in the one, leading to a corresponding improvement in the other. During the early drainage history, most of the low-lying Fen lands were kept in grass, as they could not be profitably brought under cultivation in consequence of their liability to inundations during every recurring flood. Some farmers ventured to sow a few oats on the higher lands, but it was not until May was well in and the winter rain-falls had passed away to sea. By-and-by oats were grown more largely, and wheat was cultivated to some extent.

"Then came the system which prevailed very generally in the Fens for a good number of years, and which was to let the land keep in grass for two or three years, then pare and burn, and sow with coleseed to feed with sheep during the winter months, to be followed by oats, and then wheat; and again sown down with seeds to remain two or three years, often three. This virgin soil, under such management produced coleseed of most extraordinary fattening qualities, and perhaps there has never been any natural food that would compare with it, or that would in so short a time produce so much weight of mutton. It was otherwise with the seeds, for after the first year they contained comparatively little nutritive properties, and their long countinuance on the land made a fine refuge and breeding ground for the wireworms, to which the succeeding crops oft times bore indubitable testimony; and to this day they remain the greatest foe the Fen farmer has, and it is a very unusual year when his oat-crop is not more or less ravaged by them. Probably the greatest improvement next to drainage, and consequent upon it, is the practice of claying fen lands. The value of clay, I believe, was first accidentally discovered by some of it which had been thrown from the ditches having been spread round the outsides of the field, and which produced most marvellous effects upon the growing corn crops.

. Our father's were not slow to learn, and were very soon led to adopt a system of claying which still continues, some lands having been gone over three or four times. The plan is this: pits or trenches are made down the fields, from two and a half to three feet wide, and from twelve to sixteen yards apart; two spits of clay are taken therefrom, and spread upon the intervening land, the peat or clunch subsoil being thrown to the bottom of the trench, and when all is finished, the pits are ploughed in, and the land being loose, and easily moved, is soon levelled again. The cost of claying is governed by the depth at which the clay is found from the surface of the land; but improved drainage occasioning a continual subsidence, as I have already observed, is bringing it within easy reach, and thousands of acres can now be done at a cost of thirty shillings per acre, and under; and no money expended on a Fen farm, yields so quick and so bountiful a return. The application of clay to these light soils not only gives solidity, but being possessed of considerable fertilizing properties, greatly enriches them. Happily the Fen lands very largely rest upon a clay bed; but the clay is not of a uniform quality. That which is blue and of a soft buttery nature, contains the most lime, and is the best fertilizer. Some is silty and some stony and hard, and these do little more than solidify. Perhaps the next great improvement consequent upon the drainage of Fen lands is their deep cultivation, to which reference has already been made. To talk of turning over a furrow slice thirty inches in thickness must sound to a clay-land farmer something like a piece of exaggerated nonsense; and may put his credulity to the test, but it is no exaggeration. Deep cultivation on Fen land is generally accomplished by horse power, as the great underground forest offers considerable obstacles to the application of steam. A pair of horses in a common plough go first, and take a furrow four or five inches thick, and are followed by a huge implement made expressly for the purpose, and which is pulled by six, eight or ten horses as the case may be. This plough buries the furrow turned over by the small plough, and brings the subsoil well on to the top, that its vegetable properties, by exposure to the atmosphere, may become speedily decomposed, and made available as food for plants. One object in putting the top furrow down is to get it as far as possible beyond the reach of atmospheric influences, with the idea that under these circumstances the twitch or couch and weed roots will die and decay. It certainly is a very clever and ingenious way of cleaning land, if it can only be done; but my experience and observation lead me to the conclusion that it far oftener fails than succeeds. I think land should be quite clean before it is deep ploughed. There can be no doubt but deep cultivation tends to preserve moisture in the soil in dry seasons, and to facilitate drainage in wet ones. It also unlocks those hidden treasures in which are so many elements of fertility, and consequently increases the producing power of the land. Drainage, clay, and deep tillage, to which should be added super-phosphate of lime and the water-drill, have completely metamorphosed the country, and altogether changed its modes of husbandry; and perhaps there is now no country so utterly defiant of system. Every one sows what he thinks he will, and by proportionately liberal management labors under no apprehension that his soil will become exhausted; nor will it, if he treats it generously and cultivates it wisely. Although there is no uniformity of system in the cultivation of fen lands, there is, however, a five-course-shift which has found favor, and which prevails more largely than any other, and to which several farmers pretty strictly adhere. This is the order of it: mangolds, kohl rabi, coleseed or cabbages, which are gradually growing into favor; oats, wheat, seeds, wheat. The green crops and the oats are sown with artificial manure, the farmyard manure being reserved for the wheat crops. This rotation appears well suited to the fens, and has been pursued with considerable success; but as I have intimated fen farmers break away from the restraints of system to follow their own inclinations. A ride through the fen country at the proper season will show the truth of this. In addition to the crops usually found on a farm will be seen coleseed, turnip seed, linseed, mustard, and cress growing as seed crops, and potatoes and carrots extensively cultivated for the London and other large markets. Turnips are not at all suited to fen soils. They grow of a woody, fibrous quality, coarse and long in the neck, and possessing scarcely any nutriment; they are almost valueless as food for stock, and are consequently not cultivated.

"Kohl rabi and mangolds are much better, but these, like the hay, straw, and other products of fen-lands (coleseed excepted) are very deficient in fattening properties. I have already referred to the water drill and super-phosphate of lime and their value in the successful cultivation of fen-lands. Our fen-soils appear to yield much larger supplies of ammonia than phosphates; hence the free application of phosphatic manures is accompanied by much greater and more palpable results than is the case where ammoniacal manures are used. Probably there is no part of the kingdom where the application of phosphates to the soil has produced such startling results, and especially where they have been applied with the water-drill. The fens have not been especially famed for the breeding of either cattle or sheep, but from very early times they have been noted for their good breed of cart-horses. The decreased average of grass seeds, consequent upon the increased average of corn and other crops, has largely tended to diminish the number of animals bred; but the show of cart-colts, both as regards number and quality, on the first of July of every year, is pretty good evidence that fen-farmers have not altogether lost their long-enjoyed and well-merited reputation.

"The Great Level generally, even now, under its more perfect drainage and improved cultivation, offers very few tempting residential inducements, and formerly, under other and more unfavorable circumstances, it repelled rather than invited residence. Hence it is not uncommon, in many parts of the fens, to find both farmer and laborer residing in the town or village rather than upon the farm.

"The value of fen-lands has increased or decreased just as the drainage has been efficient or otherwise. In 1651 Lord Arundel, one of the Earl of Bedford's associates, in draining the Great Level, became so discouraged by the reverses and losses sustained by the adventurers that he sold his share for 3s. 9d. per acre, the same land now being worth probably from £30 to £50 per acre. Many farms in later times have been sold at very little over their present annual rentals, and some at even less. Through the kindness of Mr. Richards, Trimblington, I am able to present the assessments to the poor rates of certain lands in the parish of Doddington, made at different periods, showing the influence which improved drainage has had upon the value of fen lands :—"

	Acres.	Rateable Value.
1736	200	£40 0s. 0d.
1784	200	60 0 0
1822	200	100 0 0
1869	200	238 0 3
1784	60	15 0 0
1838	60	21 0 0
1869	60	68 1 4
1757	20	2 0 0
1784	20	5 0 0
1869	20	26 0 0

The above statement has been written by Mr. Ruston since I enjoyed the benefit of his explanation on the ground, and he has favored me with the printed copy. His residence is in what is called the black-fens, the soil being black with muck and decaying vegetable matter for a depth of from two to ten feet. The clay, of which Mr. Ruston speaks, is the earth under the peat, and is quite calcareous. There are portions of the fens nearer the western border—for example, near Peterboro—and the Whittlesea Mere where the whole substance is black and more like turf. Such cannot be cultivated until they are burned over, so as to get an accumulation of ashes, or else are covered with earth brought from the upland, or from pits sunk through the peat down to the solid ground. Pits are sunk through the turf nine feet deep in some places, to raise the bottom earth to the surface, and the land is dressed with it at a cost of from $12 to $18 an acre. I saw good crops of grain, cabbage, and turnips growing on ground prepared in this way. The fens containing turf are, however, the most expensive and difficult to reclaim, and there are considerable tracts which have not yet been cultivated.

The parts of the fens nearest the sea-shore or on the river banks are the best. The soil contains a large proportion of sand and clay sediments, and is not liable to settle, and it needs no claying. It has been filled up by the deposits from muddy water and the wash from the river floods. It is the very best and most productive of all these reclaimed lands.

The banks which are built to confine the streams and hinder them from overflowing the country on their way to the sea, as well as those along the sea-shore, are of the most substantial kind. They are constructed after the plans of engineers, and built under their directions. Generally they do not differ from the banks of canals or other structures which are required to resist the pressure of water.. From the nature of the fen soil—the layers of peat, sand, and mud in it—great care is necessary in preparing the foundations of the banks. Those which are built now are usually six feet wide on the top, and built with a slope of two base to one rise: and to keep them firm they have a foreshore of from six to fourteen feet, and the middle of the bank is puddled with clay. This puddling is done by digging a trench three feet wide along the middle of the foundation, and sinking it down to the solid bottom. The trench is then carefully puddled with clay quite to the surface, and up as far as the nature of the materials in the bank require, in order to make them water-tight. Like all other works of this kind, there have been numerous and expensive failures in the banks from lack of good foundations. In 1862 a most extraordinary accident took place from the undermining of the sluice gates of the main drain of the Middle Level, at its confluence with the River Ouse. This drain has to carry an immense quantity of water. Its bottom is seven feet below low-water mark, and forty-eight feet wide; its sides have a slope of two base to one rise, and spring tides there have a rise of nineteen feet, so that its width at the high-water line is one hundred and fifty-two feet. The sluice gates were like canal lock gates, and in three pairs of thirteen feet each, thus making a clear water way of seventy-eight feet. The water in this drain runs out through the sluices during low water, until it almost comes to low-water mark. From some imperfection in the foundation these sluice gates gave way and the tide-waters were let into the drain. They rushed up and again poured out of the drain with great velocity, and throughout a distance of twenty miles they ebbed and flowed. This state of things continued for several days, when one of the banks of the drain burst and let the water in upon this low but rich and cultivated country, and completely inundated six thousand acres of land. The damage done by the flooding was enormous.

The method resorted to for again stopping the drain is very curious, and may be worth the description. With great pains and at a large expense a solid, strong dam was built across the drain so as to completely shut out the tide, and then sixteen syphons, each three and a half feet in diameter, were laid so as to draw the water out of the drain above the dam, carry it directly over the top, and discharge it into the drain below. The syphons are set in operation by means of a steam engine and air-pump, and they are guarded by valves so that they may not carry water up stream during the flow of the tide. They have now been in operation eight years, and have answered their purpose completely. The water in the drain flows up to the dam with a strong current, runs over it in the syphons, and then, a great river of water, it runs off in a rapid current towards the sea.

Some of the oldest of the banks are still settling, with the long-continued drainage of that country, and every year they have to make repairs, at large expense, of cracked and settled banks.

When the water in the streams is high the drains cannot discharge all the water that falls on the fens into them; and with the continued settling of the soil the sluices come to be more and more incapable of discharging all the water. When the drainage was first completed, wind-mills were used to pump the water from the ditches into the drains; but they were too uncertain in their action. When the water was abundant, and there was no wind, the lands would be overflowed, and now steam engines have almost entirely taken the place of the old wind-mills for driving the pumps. There were formerly as many as seven hundred on the fens between Lincoln and Cambridge—a few are still left, but the place of most of them is taken by about sixty steam engines, which range from ten to eighty horse power.

The water is chiefly raised by scoop-wheels, and not by pumps. These wheels are almost like the paddle wheels of a steamboat, and they are set so as to fit closely, but without touching, between parallel stone walls, and the bottom is curved upwards in front. When the wheel turns it presses the water forward in the narrow passage and upward till it is raised sufficiently to run over into the drain. Such wheels will lift economically to a height equal to one-third their diameter. The height to which the water has to be lifted varies in different localities. From two to ten feet are common cases.

Some very large rotary pumps have recently been erected for the drainage works near Boston, in Lincolnshire, and it is claimed by the ablest engineers that they are cheaper to work, and more efficient than the scoop-wheels.

The amount of water raised is enormous. At one place in the Deeping Fen the engines raised three hundred tons a minute to an average hight of seven feet, and the whole fen of 25,000 acres is drained by two engines of sixty and eighty horse power.

The way of determining the power needed for any drainage is to take the greatest rainfall in any month, make the proper allowance for evaporation, and then calculate the number of tons of cubic feet of water that will remain on the whole number of acres to be drained. Then allow that the engines can be kept at work twenty-five days in a month and twenty hours each day, which is five hundred hours a month. Then provide an engine and pump which are capable of doing the work, and the plan is completed.

The machinery and power necessary to drain these lands is now well understood, and is put in operation. The water is kept in the ditches at a level which is from two to three feet below the surface of the ground, varying somewhat with the crops that are to be grown. It is found that the presence of the water within that distance from the surface is favorable for the growing crop, and a security against drouth. The last summer was one of unexampled dryness, and the fen farmers found it was very useful to them to have water in the ditches, and great care was taken not to let the water out below a certain level; but on the contrary to dam it back so as to hold it up to the proper height.

Mr. Ruston informed me that a portion of the fen near Chatteris, in which he is interested, contains 10,000 acres, besides 2,000 acres of upland, and it is drained by an eighty-horse engine at a cost of six pence an acre per year. This is the cost for the year, but it is not by any means the annual tax, as additional to the expenses of the year, there are large debts which have been contracted and must be paid; also, parliamentary and other expenses. The tax in 1870 was 1s. 9d. an acre on most of the land, and 10½d. on the rest. The heaviest taxes that can be imposed upon these lands are 3s. 6d. and 1s. 9d. an acre. The taxes in some other parts of the fens are a little higher, being from 4s. to 6s. an acre.

The first cost of these improvements has been enormous—95,000 acres out of 300,000 were given to the first Earl of Bedford for making the drains and connected works—and there are many districts in this Great Level where farmers have combined to make additional improvements at their own costs. It is said that there are more than a hundred acts of parliament relating to the fen drainage. The parliamentary expenses are very large, as every bill is strongly opposed and must be fought through. The Middle Level has a debt of £500,000, and arrangements have to be made for paying it off within twenty years of the time it was contracted. The expense of the syphons in the Middle Level drain were £62,000. Other sums of money equally large are spoken of in connection with different parts of the fens; but it is found by experience that they are small when compared with the value of the land or its extraordinary fertility. It bears all these expenses, and continues to increase in its power of yielding productive crops and supplying food to the rest of the kingdom.

THE NETHERLANDS have long been noted for the great extent of land liable to overflow. The country itself is very flat and low and has no ranges of hills to break the uniformity of its surface. It is open to the North Sea along its north and west borders, and on the south is crossed by the Rhine, which brings down an immense volume of water from the hilly and mountainous parts of Western Germany. In North and South Holland there is a border of sand hills, dunes, or, as we should call them, beaches, along the sea, but the more southern provinces have no such protection, and are exposed to the direct action of the waves. In both, however, the country is liable to be overrun by the sea, the only difference being that the water naturally runs off quickly in the southern provinces, while in the northern the dunes hold it back and so favor the growth of turf and the accumulation of muck. Along the Rhine the country is equally exposed, and when great floods occur in that river and the water comes down to the flat country where its current is checked, it overflows its banks, covering the whole country and causing frightful damage to life and property.

In dry seasons some of the ground could be cultivated or pastured, and so support human life. But the dangers to which they were exposed obliged them to maintain a constant struggle with the floods,—and the history of the country is full of accounts of the making of dikes and their failures. At first, the dikes were made of reeds and grass, later, of logs and beams of wood; more recently of earth, and in exposed parts they are faced with stone, brush, straw and grass. The kingdom has an area of about 12,000 square miles, and full one-half of it is so low as to need protection from the water. Heavy banks or dikes are built along the shore of the sea and the borders of the rivers to keep out these floods.

The leakage water and the rain-fall were drawn off from the higher portions of this land by means of tide-sluices which opened so as to allow the water to run out at low tide, and closed, to hinder any from running in at high-water. The larger portion, however, was too low for this mode of drainage, and rain and leakage waters had to be raised by pumps. In some localities the water has to be raised only one or two feet; in others ten, fifteen, twenty, and in a few places even twenty-two feet, before it will run off into the rivers or sea.

The magnitude and importance of these works can hardly be estimated. The oversight and management of them is entrusted to one department of the Government, the Waterstaat, and there is a special corps of engineers devoted to that branch of their profession.

The chief works of drainage have grown with the exigencies of the case. At first very slight dikes would be required, but as the land was drained and occupied it settled, making it necessary to increase the height and size of the dikes, and also carrying the surface of the water in the ditches lower and lower until the sluices were no longer able to drain it off, and the erection of pumps and windmills to drive them then became a necessity. This mode of driving pumps has been the favorite one in the Netherlands for various reasons. The country is flat and the winds that sweep over it are strong and steady, furnishing an abundance of power at a cheap rate. Steam engines which are their chief competitors, require fuel, which is expensive, and in times of disturbance might not be easily obtained.

In wet seasons, or in still weather when the mills could not work, the land suffered much. This led to the growing of such crops as are least injured by water—and hence pastures and meadows are much more common than fields of grain or other cultivated crops. For the best of pasture and meadow the water in the ditches only needs to be kept eighteen inches below the surface of the soil—while for growing grain or other cultivated crops to the best advantage, the water must be kept three feet below the surface. Though windmills, then, would furnish the cheapest power, there were seasons when the country suffered greatly for want of an agent more under control. Especially was this the case where lands were entirely under water and needed to be pumped dry before any improvement could begin. It is said that ninety lakes have been drained in Holland, and while some of the smaller could be pumped dry by windmills, the larger ones needed the steady power of steam. One of the greatest engineering works of the age is the draining of Haarlem Lake, a large body of water which lay but a short distance south-west of Amsterdam.

"*The origin and history of this great enterprise is as follows: In the year 1539, the North Sea, long restrained by artificial dams and dikes, as well as by some natural ridges of sand, suddenly burst its barriers, and brought horror and desolation into the fertile flats of North Holland. Twenty-six thousand acres of rich pasture land, with meadows, cattle and gardens, were covered by the waves, and the village of Nieuwenkirk was submerged and all its inhabitants lost, in the tremendous calamity. The inundation resulted at first in the formation of four lakes, but the barriers of soft alluvial soil which separated them were gradually destroyed, and the four lakes became merged into one. The degradation of the shores also continued, until, at the commencement of the eighteenth century, the waters covered an area of 45,000 acres, with an average depth of thirteen feet below low water in the Zuyder Zee. This lake constituted what has since been known as the Haarlem Meer or Sea. The people of Holland saw with much alarm, the rapid extension of its boundaries, and at an expense of about $160,000, succeeded

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*Ann. Sci. Disc. 1853; p. 31.

in partially arresting its progress; an expense of about $20,000 per year was moreover entailed for the preservation and repair of the works of defence. More than two centuries elapsed after the time of the first inundation before any one began to dream of recovering this vast tract of country, and then, for a long period, all plans proposed were deemed impracticable. At length, on the 9th of November, 1836, a furious hurricane from the west drove the waters of the lake upon the city of Amsterdam, and drowned upwards of 10,000 acres of low land in the neighborhood. On the 25th of December following, another hurricane, from the east, drove the waters in an opposite direction upon the city of Leyden, the lower parts of which were submerged forty-eight hours, and 19,000 acres of land were inundated. The enormous loss occasioned by these two storms induced the government to determine on the drainage of the lake, and a credit of $3,200,000 was voted by the States General. In May, 1840, a commission was appointed to superintend the work.

"The first operation was to cut a canal round the lake, to isolate it from the neighboring waters, and to afford the means of navigation to the enormous traffic which previously passed over the lake amounting to 700,000 tons per annum. This canal was thirty-seven miles long, one hundred and thirty feet wide on the west and one hundred and fifteen feet on the east side of the lake, with a depth of nine feet of water. On the side next to the lake, the mouths of all water courses entering it, were closed by earthen dams, having an aggregate length of three thousand yards, made in ten feet depth of water. Other great works were executed by enlarging the sluices at various points, and erecting powerful steam engines to assist in discharging the water from the canal during the time of high water. The water of the lake has no natural outlet, being below the lowest practicable point of sluicage. The area of water enclosed by the canal was rather more than seventy square miles, and the quantity to be lifted by mechanical means, including rain water, springs, leakage, &c., during the time of drainage, was estimated at 1,000,000,000 tons. In determining the motive power to be employed, two points were to be kept in view: first, the cost of draining the lake; second, the cost of annual drainage; for, when once the work was accomplished, the site of the lake could only be kept dry by mechanical power. With the exception of a few steam engines, the wind had hitherto been the motive power employed to work the hydraulic machines used in the Netherlands to keep the country dry. And the power of 12,000 windmills, having an average aggregate power of 60,000 horses, is required to prevent two-thirds of the kingdom from returning to the state of morass and lake, from which the indomitable energy and perseverance of the Dutch people have rescued what is now the most fertile country in Europe.

"The Haarlem Meer Commissioners were convinced that the old means must be laid aside, and new ones adopted to suit the magnitude and peculiarities of their work. They accordingly determined to erect three gigantic steam engines of a peculiar construction, which was accordingly done, and the whole put in operation in 1848. These engines consume but two and a half pounds of coal per hour, for each horse power, and are capable of raising one hundred and twelve tons of water ten feet high at each stroke, or of discharging 1,000,000 tons in twenty-five and a half hours.

"A short description of one of these engines may prove interesting. It has two steam cylinders, one of eighty-four inches diameter, placed within another of one hundred and forty-four inches diameter; both are fitted with pistons; the outer piston is of course annular, and the two pistons are united to a great cross-head, or cap, which is furnished with a guide-rod, or spindle; both pistons and cross-head are fitted with iron plates, and together, with parts of the engine attached, have an effective weight of nearly ninety tons. The engine house is a circular tower, on the walls of which are arranged eleven large cast-iron balance-beams, which radiate from the centre of the engine. Their inner ends, furnished with rollers, are brought under the circular body of the great cap, and their outer ends are connected to the pistons of eleven pumps of sixty-three inches diameter each; the stroke of both ends is ten feet, and the discharge from the pumps sixty-six cubic metres or tons of water per stroke.

"The action of the engine is very simple; it is on the high-pressure-expansive-condensing principle. The steam is admitted first beneath the small piston; and the dead weight of ninety tons is lifted, carrying with it the inner end of the pump balances, and of course allowing the pistons to descend in the pumps.

"The equilibrium valve then opens, and the steam in the cylinders passes round to the upper surface of the small and annular pistons; puts the former in a state of equilibrium, and presses with two-thirds of its force upon the annular piston, beneath which a vacuum is always maintained; thus the down-stroke of the engine, and the elevation of the pump pistons and water, is produced by the joint action of the descending dead weight in the cap and pistons, and the pressure of steam on the annular piston. The engine has two air pumps of forty inches diameter, and five feet stroke each. The water is lifted by the pumps into the canal, from which it passes off towards the sea sluices. The total weight of iron employed for the engine, pumps, &c., is six hundred and forty tons. The cost of the machinery and buildings was $175,000."

"*The last openings in the surrounding dike were closed in

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*From Buysing's Waterbouwkunde.

the beginning of June, 1848, and one engine was started on the 7th of that month. The water in the lake then stood at twenty-five and a half inches below the Amsterdam Level.* On the 11th it had been lowered to thirty-two and a half inches, and after thirty days' operation the water stood at three feet below. In October the level was reduced to three feet one and a half inches, which left the banks exposed to all kinds of danger from the approaching stormy season. The two other engines were set at work February 26, 1849. In one years' time they brought down the surface of the water to six and a half feet below A. P. By this time some difficulty was experienced in bringing the water to the engines on account of its shallowness near the shores. Two of the engines stood almost exactly at the opposite ends of the lake, and a conducting drain was dug between them, which divided the lake into two nearly equal parts. A cross drain was also dug, cutting the first at right angles. They were cut to the full breadth of sixty-five and a half to eighty-two feet, but only to the depth of ten feet, and later to that of thirteen feet, equaling the average depth of the Mere, which was, for the time, satisfactory. Afterwards these ditches had to be lowered to nineteen and three-quarters feet, and in 1857 they were deepened to twenty-one and one-third feet. The last portions of water were troublesome to drain off to the pumps, and the engines could only work intermittently. In June, 1852, the water of the Mere finally disappeared, and in July the ground became quite dry. The work thus lasted four years and one month, but as only one engine worked for the first part of the time, it is considered that the whole is equivalent to three years and seven months' work of the three engines.

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*The datum plane to which all levels are referred in Holland is on a level with an established point of reference in Amsterdam. This mark is usually spoken of as A. P. (*Amsterdam Peil.*)

"The first engine made an average of from eight to nine strokes a minute, and the other two an average of from six to seven; and in the whole time nearly 14,000,000 strokes each. The whole amount of water that was raised was 832,000,000 tons."

"The total expense of the undertaking, from 1839 to 1855 inclusive, has been $3,600,000. The land was at first valued at thirty-three dollars an acre. Subsequent examination proved that the soil laid bare by the draining operations was of far greater value than was originally supposed. Thus, in 1853, 1,936 acres brought $230,000, or $118 per acre; and though subsequent sales have not realized such large prices, yet the land commanded a much higher price than the first valuation. 'This result,' says M. D'Endegrest, 'surpassed all expectation, inasmuch as the grand object of the drainage was rather to put an end to the encroachments of the lake than to make a lucrative speculation of it.' It is stated that a great number of farms are springing up on all sides, and that the cultivation of the rich land is affording employment to many hundreds of laborers. The total amount of land available for agriculture is estimated at 44,400 acres; and by proper care and supervision it is confidently expected that no water overflows will take place.

"The value of the land recovered by Holland from the Lake of Haarlem is increasing at a rate which insures payment of all the outlay for the drainage in a comparatively short time.

"No ill consequences were experienced from intermittent fevers, as was dreaded when the surface was first laid bare, and the numbers of dead fish had no other effect than to fertilize the soil."

A visit to this dry lake in 1870 proved very interesting. It is traversed by excellent roads, the ditches are kept clear, and the water is low in them, about three feet below the surface. Farm houses are located everywhere about the bottom of the lake, and trees, shrubs, and all the appendages which belong to pleasant and prosperous farmers' houses, are found here just as though they were not beneath the level of the sea. For some years after the lake was drained the lowest parts continued wet and unpromising, and the land was held at a low price, but by reducing the drainage level still further, this portion has become quite as dry as any part of it, and the soil being heavier it is now more valuable than any of the rest. With the exception of some strips along the edge, from which the peat has still to be cut or burnt off, every acre is now productive. I saw here one of those remarkable Dutch dairies; the cow stables, cheese house, and dairyman's dwelling all under the same roof, and all perfect models of neatness.

The yearly expense of keeping this Haarlem Meer *polder** dry is not great. My informant, who was a land owner in it, told me that his taxes there were ten florins per hectare, and that they were seven florins per hectare in one of the small lakes which he had drained. These prices are equivalent to $1.62 and $1.13 an acre, which is not high for the work done and the valuable service rendered in always having a full supply of water only three feet below the surface.

The success of this enterprise has led to the undertaking of several others of the same kind, and to the projection of still more. The Great Ship Canal now in course of construction between Amsterdam and the North Sea passes for twelve miles of its length through the Y, a large body of water which is about four feet deep. The canal is built by dredging out the material and depositing it in the banks on either side. After this is done it is designed to pump out the water from the rest of the Y, and thus to secure 12,000 acres of good land. This is considered entirely practicable, and the company estimate the reclaimed land to be an important part of their compensation.

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*Polder is the Dutch name for a plot of reclaimed ground surrounded by a dike.

The Zuyder Zee, though covering a large surface, is quite shallow, and the project of dyking it off from the North Sea, and then pumping the water out of it, is now under discussion. The work is one of great magnitude, and must take a long time to get in operation, but it is neither impracticable nor visionary. The whole of it covers an area of 1,200 square miles; but part of it may be divided off for completion at first. The Haarlem Meer polder includes 18,000 hectares, which this year are worth 1,200 florins per hectare, or nearly $200 an acre; and the whole is worth 21,600,000 florins, or $8,640,000.

The following rules in regard to the construction of dikes are copied from Storm Buysing's Hydraulics, the standard text-book for Dutch engineers:

"FORM OF DIKES.—Dikes in general should have height enough to turn water; and by their form and the material of which they are made they should possess strength enough to withstand the pressure which water and other forces bring to bear against them. Hence they should rise at least from twenty inches to two feet above the highest known level of the water. Their shape should be that of a trapezium. They must be made of good adhesive earth, and they must not only be mutually united together in all parts, but also with the foundation on which the dike is laid. The breadth ot the top may vary from nineteen inches up to twenty, twenty-three, and even twenty-six feet. The outer slope has an inclination of from two to eight and even ten base to one rise. The inner slope is just enough to hold up the earth; usually from one and a half to two base to one rise. It may even be necessary in some cases to give the inner slope a curved outline.

"THE FORE-SHORE.—The dikes are generally separated along their outer and inner borders from the adjacent lands by ditches, and the spaces between the ditches and the foot of the slopes are called the outer and inner *berm*. The breadth of these vary—for the outer berm thirty-three feet and for the inner one twenty feet is usually thought sufficient. Sometimes these berms are left as the natural surface of the ground raised them; but in case the land is not smooth and regular, they are often brought up to a uniform height, when they aim to lay them with a gentle slope, say one in twenty from the bank outwards, so as to facilitate the running off of surface water.

"Experience shows that the dikes which lie directly on the brink of the shore are much more liable to injury than those which lie further in, and have some land before them; and however much ideas may differ about the minimum of breadth in the different circumstances, which depend upon the position, yet all are agreed as to the supreme importance of this protection; and in laying out new dikes and diking new polders this must be looked to.

"Most of our existing systems of drainage lack this protection, and lie directly exposed to the force of the waves or current; yet these dikes once had land in front of them at most points, but it has been slowly worn away by the action of water. Now, to change the situation of the dikes is impossible, and we must limit ourselves to the employment of the best means of defence, and regulate these according to the situation.

"In laying out new dikes the first consideration is that the species of earth be suitable for making and keeping them up. Material for the outer dikes must be had without coming nearer to the dike than the outside line of the berm; that is, along the shore an edge of unbroken earth must be left of from thirty-three to sixty-six feet wide; and at intervals of perhaps three hundred and twenty-five feet jetties or projecting banks of earth twenty feet wide, standing out at right angles to the line of the dike, should be left to supply material for the repair of the dike, filling holes, or for other uses of the like character.

"Along the banks of great rivers, and along the seashore, the berm or fore-shore is sometimes made much wider, even to 325 or 490 feet.

"LOCATION.—In selecting a location for dikes on new ground, there are many more circumstances to be considered than for determining the fore-shore—first, the direction must be such that with the shortest dikes the greatest surface possible may be enclosed; second, the dike must as far as practicable run parallel with the stream or else at right angles to it, and, third, that direction must be avoided which would be exposed to our prevailing storm winds from the southwest, west, and northwest. But above all the quality of the ground on which to found the dike must be considered, and the firmest and highest possible selected, and that which is not cut up by brooks or low ground. When corners or tongues of land come in the way, it is to be decided whether their outline should be followed, or partly cut through and diked, as in cases where the cost of a longer dike may not be compensated by the increased value of the piece of land to be diked. The line of the dikes must avoid all acute angles, and when necessary, making them outward rather than inward, because they hold the water driven by the wind better than the others. Different lines can be united by curves, to which the two are both tangent.

"FOR THE CROSS-SECTION of a dike it is not enough to obtain strength, but sufficient strength to resist the force of the water on the dike must be obtained at the lowest possible cost. The height forms the first consideration; the highest water levels ever to be expected at that point form the guide to this, and observations of extraordinarily high freshets after storms give them. Those of January 14 and 15, 1808, February 4, 1825, and February 24, 1837, are the highest ever known, and rose as high as seven and a half to eight and a quarter and even nine feet above the ordinary high-water mark, varying with the position as regarded wind at the point of observation. These heights were measured with perfectly smooth water; the waves are by no means equal. Where dikes turn from the wind there are scarcely any waves, so that a dike from two to two and a half feet above the highest known water level is quite sufficient for these. While in dikes affected by the storm wind the waves rise, according to observations taken in Zeeland, as much as eight feet above still water. The waves are higher where the dike is without a berm and has great depth, than where it has a high and broad berm. They also rise on steep slopes much higher than on more gradual ones.

"The height of the dike must be most regular, sloping from those points most menaced by waves down to such parts of the dikes as are protected from the wind, where less height is requisite.

"For example, the Southern Dike, between Rammekens and Veissingen, on the island of Walcheren, is only ten feet above high tide, while it rises at Veissingen to sixteen and a quarter feet. The Westkappel Dike, which is also very favorably situated with regard to the wind, is fifteen and a quarter feet above high-water mark.

"On the Island of Schourien, when the Dike of Scharrendijke was improved in 1842–3, it was raised to twenty-one feet above high water. Other less exposed portions along the Zeeuw streams are from ten to eleven and a quarter feet above.

The Helder Sea Dike from the end of the dunes at Huisduinen on to Nieuwe Diep, running almost east and west, and consequently much exposed, is from twelve and a half to fifteen and a half feet above ordinary high tides; the other North Holland dikes along the Zuyder Zee are from eleven to twelve feet. The Gelder and Overyssel dikes average from eleven to twelve and a half feet; those in the vicinity of Vollenhoof are thirteen feet above, and those along the coast of Groningen from thirteen to fifteen and a quarter feet above.

The height above ordinary high and low water thus regulates the height given in descriptions and plans, and this is indicated by immoveable marks at different points, such as bolts, beams, or panels in sluices, or similar things. The ordinary tides are thirteen feet or less.

"The breadth of the top of the dike varies from twenty inches to twenty, twenty-three, or twenty-six feet. The first consideration here is the strength required of the dike, and the second whether the top shall or shall not be used for carriages and horses. Riding on top of the dike is generally considered as injurious to the dike and dangerous for the traveler, nevertheless it seems advantageous to give so much breadth to the tops of the dikes that they may serve as roads when needed; for in time of danger they are often of great service for the transportation of materials, while in case of overflows they afford communication for a long time when the ordinary lower roads are made impassable by the water. Hence where the ordinary roads do not cross dikes a breadth of at least ten feet should be left, while on such as usually serve the purpose of roads from sixteen to twenty feet is necessary.

"On the inner side that slope is taken at which the soil is in no danger of sliding down; the most cohesive soils will almost stand with a slope of one base to one rise, less cohesive one and a half to one, and always with an inclination of from one and three-quarters to two rise to one base. If the dikes had only to resist the pressure of the water on their sides, then (providing the dike were of good adhesive material) the cross-section might be triangular in shape, the side slopes of which should have the natural inclination of the earth; but this is not advisable, since perfect coherence and solidity are never attainable in a raised mass of earth, and this lack must be supplied by a greater amount of earth. Again, the jar of the water and the motion of the waves form the chief cause of the destruction of dikes, and hence the outer slope, which has first to resist this force, must be put in condition to withstand it.

"The force with which water and other bodies come against a slope, increases in proportion to the angle made by the slope with the horizon, hence a slight inclination affords more resistance than a steep one, which experiments have confirmed.

"According to theories advanced by Woltman on the effects produced by water and ice upon dike slopes, sea dikes are effectual with less strength at their foot than nearer the top, and a convex surface should be chosen for the outer side of sea dikes, though a smooth form should be retained where the slope varies but little.

"The consideration that the ice is never driven by low water against the dikes, but always at high tide, and that the beating of the waves against these dike slopes can be injurious only when the winds are in a certain direction and at high tide, naturally leads to the conclusion that the slope below high-water mark may be less smooth than above. As the portion of the slope below high water is unfavorable to a natural covering of grass, it must be artificially protected, and this protection is less costly with a steep slope than with a gentle one. As all sudden crossings and sharp angles are to be avoided, the outer slope should have a convex form.

"THE SPECIES OF EARTH of which the dikes are made must be such as will cohere and hold firmly to the foundation; the more cohesive the earth the more desirable it is, and the more solidity may be expected from the dike. Hence clay is the most desirable material for dikes, and it can generally be found along our coasts where dikes have been or must be laid. Sometimes they are made by preference from alluvial earth, where clay is not near, and its transportation would be too costly and troublesome.

"Sand has very little cohesiveness and will not make strong, water-tight dikes; pasture or marshy earth has too little specific gravity, frequently even less than water, and hence must be excluded with sand from the dike.

"Garden and surface soil, though far below clay, still as its fine particles readily pack, is much more desirable than pasture ground or sand, particularly for covering slopes where grass is wanted.

"The clay is not always pure, nor always obtainable in sufficient quantities, so that a mixture of clay and poor earth must often be used. But if care is taken to put the best and purest clay on and near the outer slope, and the poorer kinds in the body of the dike, then such kinds may be used without much danger. There are instances of dikes made from very sandy soils, with a covering of only three feet of clay on the outer slope, which, nevertheless, turned water well. Such layers of clay should be used with the utmost care and every little injury must be immediately repaired, for if the ground once give way so far as to admit the water to the sand or poor earth, little dependence can be placed upon stopping the water.

"Before commencing the making of the dikes, direction and profile are carefully marked out on the ground, and the precise borders of the inner and outer banks, marked with a sharp instrument. Within these the sods are torn up as much as possible, and the ground always dug up deep seven to eight inches, made soft and cleared from all roots of trees, plants or anything which might hinder the proper cohesion and union of the soil. The sods, both from under the dike and from the ditch, are to be carefully piled up to be afterwards used in covering the new work. As the outline of the dike and size of the ditch are enlarged, it will seem that the new dike is to be higher than that previously calculated for, for the earth is not so firmly united when first dug out as it subsequently becomes through the weight of the dyke and the evaporation of the water, but the subsoil will also be more or less pressed down by the weight of the dike until the resistance of this packed subsoil equals the weight imposed. It is difficult to give a definite idea, as the position of the foundation depends upon the nature of the ground, the weight of the dike and the extent of the surface necessary to support this weight. The greater or less sinking of the body of the dike depends partly on the greater or less firmness and humidity of the soil, but also much upon the carefulness of its treatment. So the height of the dike is made one-seventh or one-tenth greater according as more or less sinking is expected, but the breadth of surface remains the same that it is to be after the final settling of the height of the dike, so that the inclination of the two slopes is steeper. But since the top of the dike will sink most, as most earth is heaped there, and the ground has at just that point to bear the most weight, while on the contrary there is no sinking at the foot of the slope; after its final settling the dike will have less inclination.

"The banks are built in thin layers and packed by the constant passage of horses and carts, and sometimes by means of stamps or by puddling.

"The planting of dikes with trees may be very advantageous; along genuine sea dikes it is impossible to keep them alive; but dikes less immediately exposed to the sea air are often planted with trees. The rapid drying of the dikes renders the growth of wood slow, and the grass grows thin and poor under them, while the motion of the trees in high winds, affecting the roots, loosens the soil, so that it seems unadvisable to plant dikes where trouble in resisting the water is anticipated. Whenever there is an opportunity to plant osiers and willows along the dike, at a distance of twenty or twenty-six feet, such planting is highly desirable for it destroys the power of the waves and of ice, thus strengthening the dike. The osiers and willows are generally cut every three or four years. In order that the dike may never be exposed, an arrangement ought to be made to cut a part every year, so that the larger portion of the protection may remain standing."

In concluding these statements regarding the success which has attended drying the low-lying lands of England and Holland, I may call attention to several points separately.

1. From the statements made it is obvious that the reclamation of salt marshes or lands liable to be overflowed by the tide is attended with a heavy outlay of money. In the English fens the expenses have come in so many forms that it is not possible to get them together, but they have been enormous. In the Netherlands, also, the expenses have been wonderfully large; the dikes on the Island of Walcheren, which is on the most exposed part of the coast, have been several times almost destroyed, and it is said they have cost money enough to build them of solid copper. In our own State the Swartwout improvement on the Passaic and Hackensack marshes, in 1830-6, failed from not being thoroughly carried out; and the later enterprise of the nurseries on the same ground, was brought to an end from an unwillingness to invest money enough in it to construct substantial banks and sluices to

shut out the tide and drain off the water; and in our southern counties where diking is a success, there have been many heavy losses from the failure to put in a sufficient amount of money and labor to build solid and permanent banks. To make the dikes stand they must be built of earth, or at least must have a core of earth, and not be entirely of peat or spongy sods. The foundations must be more carefully prepared. Along the banks of rivers and streams the ground is usually solid enough to hold up the dikes, but it should always be sounded for old sloughs or water-courses, which, though covered with solid earth, may still be very soft and insecure. In all banks crossing the marshes away from the water-courses the material of the marsh is soft and yielding, and secure banks can be built on such ground only by making a core of puddled earth in the bank from the solid ground under the marsh up to high-water mark. The peculiarities of our marshes in respect to solidity of material were plainly shown in the maps accompanying the Geological Report for 1869.

The expenses of reclaiming lands will be least when the largest plots are enclosed within the same bank. The bank for a large plot needs to be no heavier or higher than for a small one.,—and the lengths of bank to go around fields of the same shape are in proportion to the square roots of their areas. It takes but twice as long a bank to go around four hundred acres as it does to go around one hundred,—but three times as much to go around nine hundred acres—and only four times as much to go around sixteen hundred acres. The Dutch *polders* or plots of enclosed and drained ground formerly averaged about twelve hundred acres each, but the newer ones are much larger; the Haarlem Meer polder contains 45,000 acres, and all the projected new ones are very large. The drainage districts in the English fens are also very large, the smallest of them including many thousand acres. It is by dividing the expenses over so many acres that they are made light enough to be paid and still leave the farmer a margin for profit.

It should also be remembered that when our drained lands settle so much that they cannot be longer drained by sluices, then pumps will have to be used. The amount of rain that falls in this country is nearly double that of England or Holland, and, of course, will cost twice as much to pump it up so as to run it over the dikes.

And finally when such costly works are to be undertaken, the plans for their location and construction should be entrusted only to skilled engineers and workmen. By this means the parties interested may have a fair understanding of the expenses they must meet, and also a reasonable prospect that their improvement will be a permanent one when done.

2. *The worth of these lands when properly reclaimed can hardly be overestimated.* Wherever there is a sufficient amount of clay or mud mixed in with the grass roots and other organic matters of the marsh it will make a soil inexhaustibly rich. When such lands are brought into cultivation, with good management, they can always be depended on for yielding large crops. They are easily tilled, and cost less than other lands for fertilizers. The water level being only two or three feet below the surface, crops upon them are very little, if at all, damaged by droughts.

It should, however, be distinctly understood that marsh lands are not all composed of soils like those mentioned above; very large portions of marsh lands are found in which there is no earth, clay or mud, nothing but muck and grass roots or turf. Such lands will not produce crops without manure; and to make them really good soils, they must be clayed like the English fen-lands, which have been described, or else have upland earth put on them to the amount of two hundred or three hundred yards per acre, and must be fertilized with mineral manures like uplands. Lands of this quality will sink very much when drained, and in many places may become so low as not to be capable of drainage by sluices; and they will very soon need pumps to drain them. When remote from market, it is very questionable whether it will pay to give them the *thorough* drainage which is needed for cultivated land. In the neighborhood of Salem some of the drained meadows are only used for growing grass, and not cultivated. This is the case also in Holland, where by far the largest part of the drained land is in meadow or pasture, and is considered to be more profitable than the arable land. The water needs not to be kept so low in the ditches, the cost of drainage is lessened, and damage from floods is much less to be dreaded. Pasturage and the raising of hay may possibly be adapted to these flat grounds to an extent much greater than has yet been reached.

The improvement is well begun, both in East and West Jersey, and there is abundant encouragement for continuing it. There is room, however, for failures, and every project for drainage should be carefully examined and well understood before its execution is undertaken.

3. The effect of draining marsh lands upon the health of the adjacent country, is a most important subject of inquiry. The English Fens were formerly noted for generating fever and ague. They are universally conceded to be much more healthy now than before they were so well drained. And though I inquired frequently, I could not learn that the drained lands were considered less favorable to health, than the drier uplands. In Holland one of the strong inducements to drain the Haarlem Meer was to do away with the sickness which followed the floods, overflows, and consequent stagnant water caused by storms driving across the lake. No injury to health has been observed to follow its drainage.

There was some sickness in the polder in 1868, but it was not serious, and there is no reason for connecting it in any way with the drainage.

Some lands in our own country are said to have been made unhealthy by drainage for a year or two after the work was done; and such might possibly be the case with these newly drained land. It is not likely to be so however, and in the end the general healthiness of the country must be improved.

Musquitoes and green-headed flies, those pests of our salt marshes, would certainly find a less favorable breeding ground if the water was all drained from the surface, and this of itself would be a great saving to the community. It would tend greatly to the comfort of human beings, and would save the stock of the country from a vast amount of worrying and loss of flesh. I saw a few gnats in the English fens, but none in Holland. The season was late, however, when I was in the latter country.

Our muskrat, which is so troublesome to the managers of dikes, is quite unknown in Europe. They have a water-rat which burrows in the banks of streams, but he is by no means equal to our muskrat in his power to do damage.

In writing these cautions in regard to planning and managing works of drainage, I do not desire to discourage them, for such lands are by far the most profitable and productive ot any that I have seen abroad. We have large areas of lands capable of such improvements; it is for the interest of the owners and of the whole community to have them improved. And the experience which has been gained both at home and abroad is sufficient to indicate the proper way of making them.

III.

On the Soils of the State, their Origin, Chemical and Physical Properties, Distribution, and Suggestions for their Most Productive Management.

A large number of soils have been collected from different parts of the State, and most of them have been analysed. There is, however, much more to be done in this department of the survey, and the results will be presented together in a special report upon the subject.

For the purpose of calling out information which may be in possession of some of our intelligent farmers I reprint from the report of last year the average of a large number of soils and subsoils, from the rich valleys of our own and the neighboring states, which are underlaid by magnesian limestone. The first column gives the soils and the second the sub-soils.

ANALYSES.

Silica	67.88	65.31
Per-oxide of iron	4.57	8.11
Alumina	12.88	13.10
Oxide of Manganese	.44	.37
Lime	.96	.59
Magnesia	1.47	1.34
Potash	2.90	3.87
Soda	.43	.69
Phosphoric Acid	.78	.80
Sulphuric Acid	.03	.04
Organic Matter	6.61	3.72
Water	1.61	1.70
	100.56	99.64

These soils have been noted for their fertility, and have been cultivated ever since the first settlement of the country. They are specially adapted to the growth of wheat, and have always yielded good crops even under the worst of management. The analysis shows that they contain an abundance of all the essential elements of fertile soils; the phosphoric acid, potash, lime, magnesia, and sulphuric acid. The practice of farmers is to enrich these soils by the addition of lime, and by raising clover. It is not thought profitable to keep any stock upon them except sufficient teams to do the work. Plans to increase the supplies of barn-yard manure, like those pursued in less favored soils, are not thought necessary. Lime causes the mineral ingredients to become soluble, and clover supplies the elements of ammonia.

For comparison with these I present the analyses of two soils from the Miami Valley, in Ohio. The Specimens were collected by my associate Prof. Jacob Cooper, and analysed in the state laboratory. The first was taken from a fence border and has never been cultivated. The second is from a field which has been cultivated eighty years without manure and still yields excellent crops.

ANALYSES.

Silicic Acid and Sand	57.60	65.20
Per. Oxide of Iron	2.23	3.78
Alumina	2.18	3.89
Lime	9.43	4.65
Magnesia	4.44	3.90
Potash	0.23	0.43
Phosphoric Acid	0.29	0.29
Sulphuric Acid	.11	.11
Carbonic Acid	10.35	5.85
Chlorine	.03	.02
Organic Matter	9.70	7.23
Water	3.05	4.10
	99.64	99.45

Analyses like these joined to the experience of farmers in working the soils, must finally help to explain some of the difficuties in agricultural science, and I would invite correspondence on the subject.

IV.

On the Iron and Zinc Ores of New Jersey.

The mining of iron ore has been actively carried on during the past year. No accurate statistics have been collected to show the whole amount that has been mined, but it is said to be considerably larger than in any former year; and the demand for our ores is increasing more rapidly than the supply. It is proposed to re-examine and extend the survey of our magnetic-iron ore district the coming season. An examination of some of the large mines of magnetic iron ore in Sweden will furnish a subject for comparison with ours, and a report upon our mines, embodying also the results of the visit to the Swedish, German, and English iron mines, will be prepared as soon as possible.

The zinc mines of our State continue to yield an abundance of ore of the best quality.

V.

Additions to the Scientific and Economic Geology of the State.

THE COPPER ORES OF NEW JERSEY.

Ores of copper have been found in various places since the first settlement of the State. The mines at Belleville, Somerville, Flemington and New Brunswick, have been woked at different times for a hundred years past.

The ore is disseminated through the Red-sandstone or is found near the meeting of that rock with the trap. It is not uniformly distributed, and mining it has not been profitable.

There is an immense quantity of rock discolored by the one or two per cent. of copper which it contains, and some of the new processes for extracting copper show ore as lean as this to be worked with profit. While abroad I visited the copper works at Stadtberg, some thirty miles west of Cassel, in Germany. A thick stratum of black and flinty slate that contains from a quarter per cent. to two per cent. of metal is the source from which the copper is obtained. The ore or rock is partly worked in an open quarry, and partly by underground mining, and being in large quantity is got out at small expense.

When visited in October the mine was producing about 2,500 tons of ore a month, and the average yield of copper was one and a half per cent. The metal is extracted from the rock by acids, and not by heat and furnaces, as is usually done.

The ore is taken directly from the mine without roasting or drying, and is crushed to fragments. The pieces are not as large as hickory nuts, but the greater part are of an appreciable size and not in powder. This crushed ore is put in vats of perhaps a hundred tons capacity, and is then covered with dilute muriatic acid; the quantity of acid being regulated so as to suit the amount of metal in the rock. The acid is drawn off at the bottom of the vat from the rock, and pumped on the top again several times in the course of the three or four weeks required to extract the copper. The liquid which holds the copper in solution, when it has been brought to a proper strength by acting on different vats of ore, is run into a vat where it can be kept in motion by a revolving agitator, and scrap sheet iron is added to it to precipitate the copper. It is soon entirely separated from the liquid, in the metallic state, but in the form of powder or small spongy grains. This precipitated copper is separated from the remaining scraps of iron by tumbling them in a cask perforated with holes through which the copper gradually sifts out. The copper is then taken to the smelting furnance and refined and prepared for market in the usual way.

The whole process is carried on very economically, labor is low, not more than one-third of our prices, and the acid is cheap, being the waste product from a soda factory; costing from one and a half to two cents a pound at the works; the liquid from which the copper has been precipitated is used over and over again as long as there is anything valuable in it, and the sediment of oxide of iron which settles from the waste liquids is dried and used for paint. The ores which contain five per cent. or more of copper are picked out and worked in the dry way. The buildings and apparatus are of the most inexpensive kind—mere sheds answering for the former, and wooden vats backed with clay being all that is used for holding the large quantity of rock which has to be acted upon by the acid.

With very careful management the process has been carried on profitably, even upon ores containing only a quarter of one per cent. With the present low price of copper, however, the managers are not so well satisfied with the profits as they have been.

An immense quantity of ore as rich as that of Stadtberg can be found in New Jersey, and descriptions and localities of it are given in the Geology of New Jersey, pp. 219–224 and pp. 675–680.

When at the German works the question arose as to whether the process used there upon the hard black slate was applicable to our softer and more ochrey rocks, and for the purpose of testing this question, some trials have been made in the State Laboratory, upon two of our New Jersey ores, with the following results, viz:

1. A common sandstone, discolored with the green carbonate of copper which appeared to have penetrated it everywhere, was analyzed and found to contain two per cent. of copper. This sandstone was pulverized and mixed with two and a half per cent. of commercial sulphuric acid. After di-

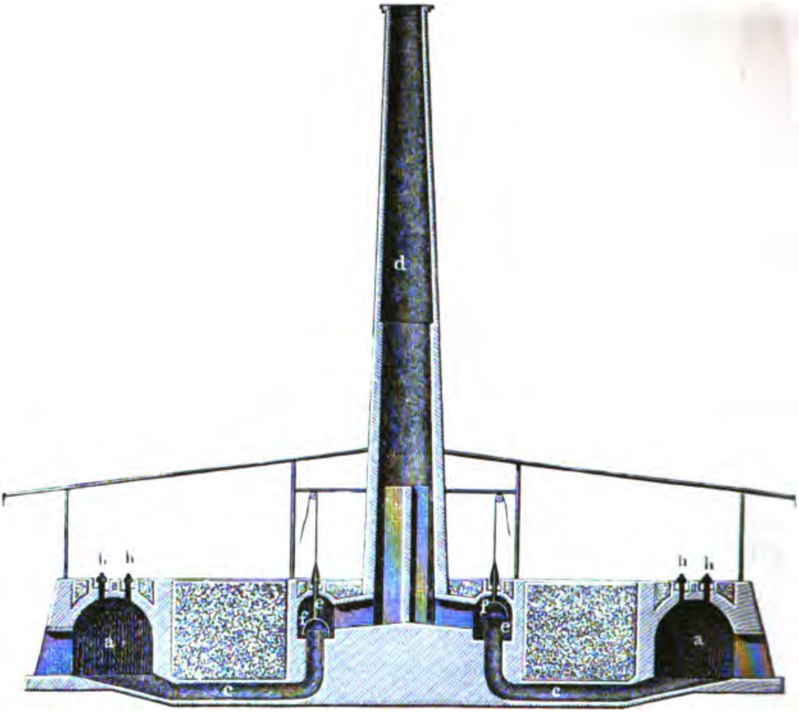
gestion the liquid was drawn off, and the copper that had been dissolved was precipitated. About one and two-tenths per cent. of metal were obtained from this first digestion, and very little of the oxide of iron or alumina in the rock was dissolved.

2. A specimen of shale, blue with carbonate of copper was analyzed and found to contain six per cent. of copper. A quantity of acid more than sufficient to dissolve the oxide of copper was put on the crushed ore and digested. The proportion of copper dissolved was not so great as in the other, and the acid was consumed in dissolving a quantity of carbonate of lime and magnesia which exist naturally in the rock.

The experiments show that the process is applicable to our copper ores in Red sandstone rocks which contain oxide of iron and alumina, but is not applicable to those which contain much carbonate of lime or carbonate of magnesia.

ON BRICK MAKING.

The use of bricks for building, is constantly on the increase in all the older sections of our country. And the advancing price of lumber must tend still further to turn the attention of builders to bricks as a material for construction. We have immense beds of brick clay both on the east and west sides of the state, lying on navigable waters, so that they are within cheap communication of the great markets. While in Berlin I had an opportunity of witnessing the working of a new form of Brick Kiln which is said to require only a third or even a quarter as much fuel as the old mode of burning. Berlin is almost entirely built of brick, two hundred million large brick are used there every year, and they are all burned in these new kilns, the older mode having been entirely driven out of use there, since 1859, when the present were introduced.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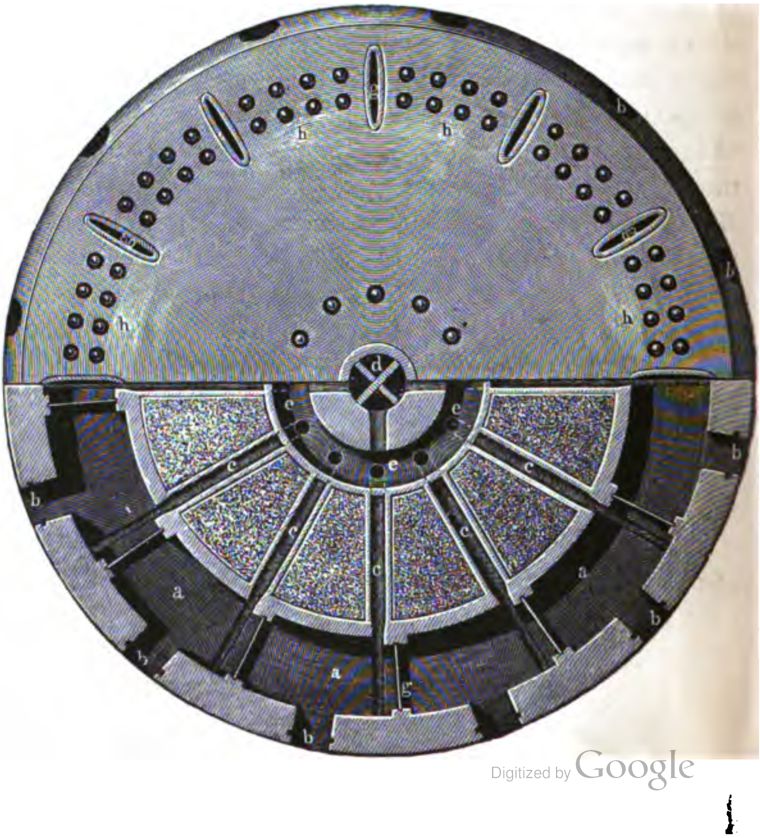
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The ingenuity with which these kilns have been made to apply well known principles of science, and the success which has attended their introduction abroad, leads me to present an illustration of them, in plan and vertical section. The kiln is a permanent structure built of bricks, and the burning is carried on in an arched passage way that has the form of a railroad tunnel, only it curves round so as to return into itself and so make a complete ring. The letters *a. a. a. a.* in the cuts show this chamber. This is connected with the chimney *d. d.* by several flues, in the cut twelve, marked *c. c. c. c.* The ring-like chamber or passage has doors or openings *b. b. b. b.* entering it through the outer wall. There are as many of these as there are connecting flues, and it is intended to have as many of each as there are working days from the time of putting in the green brick to the time when they can be taken out, burned and cool. This kiln is for twelve days work. The flues on their way to the chimney pass into an annular chamber marked *e. e. e. e.* where each one is provided with a seperate valve or stopper *f. f.* The vertical section shows one open and another shut. Between each two doors or openings *d.* are grooves built in the side walls, into which dampers or partitions can be lowered as shown in *g. g. g.* on the part of the plan which has the covering represented. By means of these the whole chamber can be divided into twelve compartments each with a flue and doorway. When working however only one damper is in its place, all the flues are closed except one, and all but two of the entrance doors are bricked up. The round openings marked *h. h. h. h.* are intended for dropping in the fuel, and are usually covered with a loose piece of sheet iron, or brick. All the space inside the annular kiln is filled in with sand or other cheap material.

The working of the furnace can now be easily understood. If the observer is supposed to face one side of the furnace where he can see the two open entrances which may be numbered (1,) (2,) and so on from right to left, he will see men placing green bricks in the compartment (1) and taking out finished bricks from (2). The damper or partition is in between (12) and (1) and the flue from (12) is open. The fuel is being fed in small pieces at a time, into (7.) This is done by dropping it through the small holes in top of the arch, and allowing it to fall among the red-hot bricks which were laid in so as to allow of this mode of dropping in the fuel. As the kiln is in constant operation and each day a new compartment is filled and one emptied, it will readily be understood that (3,) (4,) (5,) and (6,) are filled with brick which have been burned respectively four three two and one days, and that (8,) (9,) (10,) (11,) (12,) are filled with unburned bricks that have been in respectively five, four, three, two, and one days. The air which is to consume the fuel to burn the bricks is entering at the openings (1) and (2) and is drawn through the burned bricks taking up heat from them and growing hotter and hotter until by the time it reaches the fuel it is almost red hot, and ready to make a genuine hot blast for the fire and it does make a remarkably hot and clear fire. The air and gases from the combustion then pass on through the unburned brick, heating warming or drying them, and giving up its own heat so that when it reaches the chimney it is almost cold again. To-morrow (8) will be fired, and so on.

In principle it is admirably arranged, and in practice it burns the bricks evenly so that very few are damaged,—the labor of firing is very light, and needs no skill,—the amount of fuel is small, much less than in the ordinary kiln, and the quality of the fuel is very common; coal dust, chips, fine peat or any other refuse that will burn at all, can be used:—our anthracite coal dust should find a use in this kiln.

I visited the works near Potsdam where many of the bricks for Berlin are burned. There were thirty of these kilns within a circuit of two or three miles, each of which was turning out from one and a half to three million bricks a year. The fuel used is a poor quality of turf, very light and crumbling, worth at the works two and one fourth thalers a klafter, or about fourty-four cents a cubic yard, which is the quantity they were using to burn one thousand brick. The size of the brick is eleven inches by five and a half by two and three-fourths, which is twice as large as ours.

The kiln is patented by Frederick Hoffman of Berlin, and he has already three hundred of them in Prussia, and as many more in different countries of Europe. In our own country twelve or fourteen of them have been put up, and are now in operation. Hoffman's agents in this country are Wedekind & Dueberg, Baltimore, Maryland. They have a kiln there in which they claim, to turn out 15000 brick daily, with a consumption of one ton of coal or at an expense of thirty-three cents a thousand, for fuel.

The kiln is equally well adapted to the burning of lime, or of pottery.

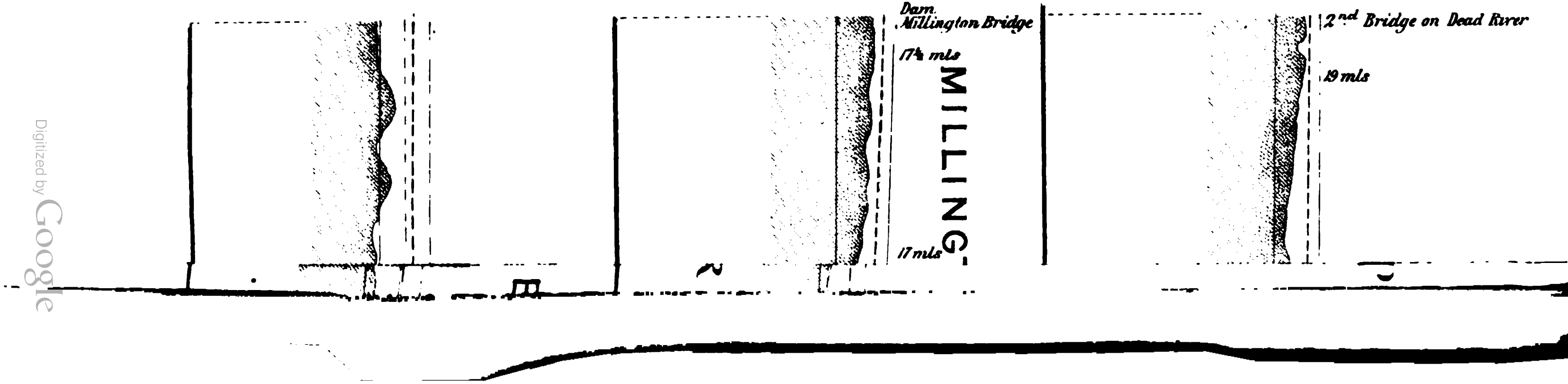
If so large a saving as that of two thirds the fuel, can be effected, by this invention it is a matter worthy the attention of our brick makers; and I gladly call attention to it.

ON THE DRIFTING SANDS OF THE SEA BEACHES.

When in Holland my attention was called to the care taken to fix their sand dunes, and prevent them from drifting over the meadows and cultivated grounds. For this purpose they plant common *beach grass*—known to botanists as the *Arundo arenaria*, *Ammophila arundinacea A. arenaria*, *Psamma arenaria*, *P. arundinacea*, and in Gray's and Wood's botanies as *Calamagrostis arenaria.* It is known by the common names of *sea-reed*, *sand-reed*, *bent*, *marrum*, and *star* or *mat-grass.* The same species which grows in England and Holland, is found on our seashores. It grows in the dry, drifting sands of the sea beaches, and thrives nearer to the salt water than any other dry-land plant of vigorous growth. All domestic animals reject it as food, but its numerous wire-like leaves successfully withstand the blasts of wind and sand which are driven across the beaches, and retain their erect position, and with their thick matting, tough and spreading roots, restrain and hold in place the drifting sands which otherwise continue to move inland, overwhelming and destroying everything in their way. When this grass gets well rooted it holds the sand, and makes it a protecting barrier instead of a moving destroyer. This property has been so well understood abroad, that stringent laws for its protection have been passed in England, Scotland and Holland, and they are strictly enforced. In England it is a penal offence for any one, the lord of the manor not excepted, to cut or pull the *sand-bent*, or to be found having it in possession within eight miles of the coast.

The sand-dunes along the coast of Holland, almost west of Amsterdam, are entirely bare of trees, and some of them nearly one hundred feet high. The winds sweep across them with more violence than any of the storms that visit our coast, yet they are held in place by this grass. The Great Canal from Amsterdam to the North Sea cuts directly through them down to the sea level, and the sandy banks of the canal are being planted with this grass at once. That set out last spring had grown and was covering the surface well, and the work of planting was still in progress when I was there on the 18th of October last. The grass is propagated by transplanting its roots and not by sowing the seeds. The plants are taken from any old plantation where the sand is full of roots. From five to ten spears of the grass with good roots, are set together in the loose sand, holes for the bunch being opened with a common trowel to the depth of from eight to twelve inches. They are set in rows eighteen inches apart, and the plants are eighteen inches apart in the rows. The work was done in the same way that cabbages are set out, and very rapidly. In that climate there was no difficulty in making the plants grow.

The sea is making great inroads on our shores; two Surveys, made about thirty years apart by the U. S. Coast Survey, show that our entire coast from Sandy Hook south for twelve miles, has either washed away or been moved inland nearly a hundred yards. Probably the same thing is true of the entire coast to the south point of Florida. This sea-bent is one of the easiest means of holding the sea in check. Our beaches will grow cedar and other valuable timber if the force of the wind can be checked long enough for them to get started. Hitherto no care has been taken to preserve the timber on the beaches, but whenever it was wanted it has been cut off, and the ground left open to the full sweep of the winds; soon the sand is all in motion, moving inland. New growths of wood could soon be started if the sand was fixed by a mat of grass. Our climate is hotter, and it may be necessary to have more regard to the season, transplanting in spring or autumn rather than in the heat of summer. In some places the land washed away is of little value, but in others it is very important in itself and for the protection it affords to other property. Premiums from our agricultural societies might be used to call out competition in the cultivation of grass or trees on our sea beaches.


Dam.
Millington Bridge
17¼ mls
MILLING
17 mls
2nd Bridge on Dead River
19 mls

APPENDIX A.

Report of Levels and Soundings taken on the Passaic River from Chatham to Millington Bridge, and also on Dead River, by Prof. Ed. A. Bowser.

A line of levels was run from Chatham Bridge to Millington Bridge, and also on Dead River as far as the second bridge from its mouth. From these levels the heights of the benches were determined at all the intervening bridges. The heights along the surface of the water were found by leveling from these benches. The heights along the *bottom* were determined by sounding in the channels of the rivers, and subtracting the depths from the heights of the surface. In the accompanying profiles, the top of Beatty's Dam, at Little Falls, is the datum plane. The heights of the points, both along the surface and the bottom of the rivers, were measured from this plane.

It will be seen, by a careful examination of this profile:

1st. That the bed of the Passaic from Chatham Bridge to Page's Dam, has a rise of twenty feet, while each dam, viz: the first just above Chatham Bridge, the second, Edward's, and the third, Bunnell's, backs the water up to the dam next above it.

2d. That the bed of the river from Page's Dam to Smally's Bridge, distant eight miles, following the course of the channel, has a rise of six feet, while the bed of the river at Smally's Bridge is two feet *lower* than the top of Page's Dam.

3d. That the bed of the river from Smally's Bridge to t
mouth of Dead River rises five feet; from the mouth of De
River to the bridge opposite the Church, two feet; fr
the Church Bridge to Millington Bridge, five feet. On De
River, from its mouth to the second bridge three miles up
rises eight feet.

We see then that while the river, from Page's Dam do
to Chatham Bridge, has a sufficient fall, Page's Dam m
back the water up to the mouth of Dead River. So that
ordinary rain, when the mill-pond is full, will flood t
Passaic Valley from the dam to the mouth of the De
River.

By the "New Formula," deduced and used by the Hyd
graphical party, in their investigations on the Mississippi
fall of eight inches per mile, in a stream the size of t
Passaic above Chatham, will give it a velocity of about c
and a half feet per second. This fall can be obtained
cutting Page's Dam down eight and seven-tenths feet, whi
will make the grade line at the dam thirty-seven seven-ten
feet above the datum plane. This grade line prolonged w
strike Bunnell's dam two feet below the top, or thirty-sev
feet above the datum plane. Bunnell's Dam, therefore, w
require cutting down two feet.

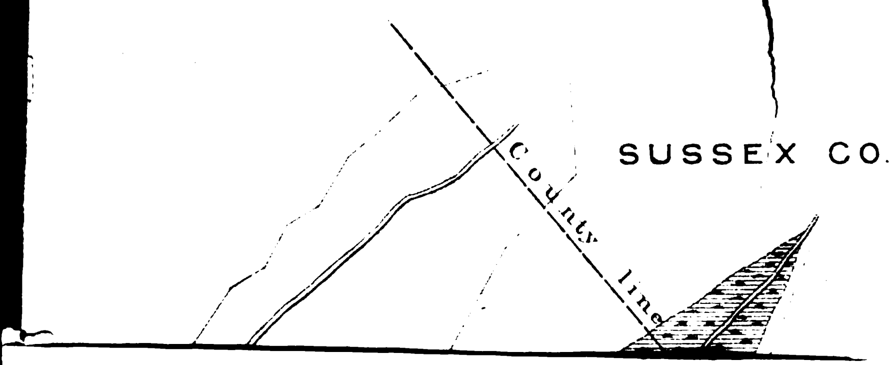
The grade line between Page's Dam and Turkey Brid
as the profile indicates, is from two to three feet below t
bed of the channel, and about half a mile above Page's Da
it is five feet below the bed, and the bottom is rock. I
tween Turkey Bridge and Townly's Bridge, the bed of t
river, wherever the grade runs below it, is mostly loo
earth and sand bars, which, with a little work, will be wash
away by the action of the running water when all obstru
tions below Turkey Bridge have been removed. At Townly
Bridge the grade is forty-one and one-half feet above t
datum plane, or one foot below the bed of the channel. Fro

this bridge to the mouth of Dead River, and on Dead River, to the second bridge, the grade is from one to three feet below the bed of the river.

Dead River and the Passaic, for half a mile below the mouth of Dead River, have at present a *fall* sufficient to carry off the water if the obstructions below were removed, but they are entirely to *shallow*. For this reason it will be desirable to cut them down to the grade line to furnish a channel sufficiently deep to keep the water within its banks and below the surface of the ground. The work of doing this will not be great as the most of it is loose earth, not having had any current to wear it away. From about half a mile below the Church Bridge up to Millington, there is at present a large fall. To drain this valley, then, requires that the bed of the river be cut down to this grade line; and this will necessitate the destruction of Page's Dam and at some future time the lowering of Bunnel's Dam.

When this is done, and only when this is done, the Valley of the Passaic from Millington to Chatham, and also the Valley of Dead River, can be well drained.

The principal cost of this improvement will be in paying for water-power that will necessarily be destroyed.


SUSSEX CO.
County line

APPENDIX B.

Report of the Levels and Soundings taken on the Pequest River, in Warren County, by Prof. Ed. A. Bowser,

A bench, named first bench, was made on a maple tree on the right bank of the Pequest, 2,286 yards below Vienna, at the entrance of a valley running up towards Danville Church. The datum plane was assumed ten feet beneath this bench. A line of levels was run from this bench up the Pequest to Adam's Bridge, and also up Trout Brook to Trout Brook Bridge, and benches established at all the bridges and at intermediate points. The heights along the surface of the river were obtained by leveling from these benches. The heights along the bottom were determined by sounding in the channel, and substracting the depths from the heights of the surface. The heights of the points, both along the surface and the bottom of the river, were measured from the datum plane ten feet beneath the first bench.

By inspection of the profile, we see that the bed of the river, from first bench to Steam-mill Bridge, has a rise of ten feet, while the rise from first bench to the bed of the river, one hundred and ten yards above Steam-mill Bridge, is only four and a half feet, making the bed of the river at the latter place five and a half feet lower than it is just below Steam-mill Bridge.

The water in the river just below the Steam-mill Bridge, on April 14th, 1870, was three feet deep, while one hundred and ten yards above the bridge it was eight and a half feet deep, and two and a half feet deep on the surface of the meadows. If the bottom of the river, from the point one hundred and ten yards above the bridge where the water was eight and a half feet deep, could be made to have a fall sufficient to give the water a velocity of at least one and a half feet per second, its surface would be kept five feet lower than it is possible to keep it with the present reef at and below the bridge. If this had been the bottom on April 14th, the water surface, being five feet lower, would at that time have been two and a half feet below the banks.

By applying the "New Formula" used by Captain Humphrey and Lieutenant Abbott in their investigations on the Mississippi, we find that, in a stream the size of the Pequest on April 14th, a fall of one foot per mile would give it the above mentioned velocity of one and a half feet per second.

The grade line on the profile represents this new bed from the bottom of the river one hundred and ten yards above the Steam-mill Bridge, down towards first bench, with a fall of one foot per mile. It will be seen that at the Steam-mill Bridge the grade is eight and three-tenths feet above the datum plane and five and a half feet below the bed of the river, which is rock. At the first bridge above Vienna, the grade is four and three-tenths feet below the present bed of the channel—the latter rock—and continues from two to five feet below the bed of the river for three hundred yards. Just below Vienna Bridge is another reef three feet above the grade. Between Steam-mill Bridge and the first bridge above Vienna, there is considerable loose earth and some rocks, besides the three reefs, varying from one to three feet deep to the grade line.

It will be seen that the grade does not run below the bed of the channel between Vienna Bridge and first bench, while it reaches the latter five feet above the datum plane, or one and one-third feet above the present bed of the channel. Thus we see that the reef at Steam-mill Bridge can be cut down five and one-half feet, and the bed of the channel from that point down have a fall of one foot per mile, without any cutting below Vienna Bridge. This will be equivalent to removing a dam from Steam-mill Bridge, five and one-half feet in height.

The grade line on the profile, with a rise of one foot per mile, reaches Long Bridge eighteen feet above the datum plane, and five feet below the bed of the river. Although the Pequest above the Steam-mill Bridge, after the bed below the bridge is cut down to the grade, will have *fall* enough, yet the present channel is entirely too *shallow* to carry off the water. For this reason it will be necessary to cut it down to the grade line, which is from two to five feet below the present bed. The river will then be deep enough to carry off the water without overflowing its banks, and still have a fall of one foot per mile. As the bottom of the river along this meadow is mostly mud and sand-bars, it will not be difficult to make it two or three feet deeper. From Long Bridge up to Adams' Bridge, the rise is five feet; from Long Bridge to Trout Brook Bridge, it is six feet. A fall of three feet per mile can be obtained here, and the channel dug deep enough to keep the land dry.

PROPOSED CUT-OFF.

The profile of the "cut" from the Pequest, one hundred and ten yards above the Steam-mill Bridge, through by Danville Church to the Pequest at first bench, and also that of the branch cut striking the Pequest four hundred yards above first bench, represents the heights along the surface of the ground above the same datum plane that the heights on the river are referred to.

The grade, represented in the profile, leaves the Pequest at a point one hundred and ten yards above the Steam-mill

Bridge, and eight and one-third feet above the datum plane, —which, it will be seen, is in the grade line drawn in the profile of the river—and, with a fall of two feet per mile, reaches the Pequest at first bench five and six-tenths feet above the datum plane; or, by the branch cut, reaches the river five and ninth-tenths feet above the datum plane. Both of these routes were leveled for the purpose of ascertaining which would be the most favorable one for the "cut" that the citizens of Danville and Vienna have talked of for some time as being more favorable to the draining of the Great Meadows than the present channel of the river.

By reference to the profiles it will be seen that the cut to the first bench will be fifty six feet deep at the highest point, and the other forty-nine feet; and that the latter is shorter than the former by seven hundred and fifteen feet.

With a cross section of thirty feet bottom, and a slope of three base to two rise the excavation in these cuts down to the grade line will be as follows:

	Cubic Yards.
From one hundred and ten yards above Steam-mill Bridge to junction of cuts....................	77,365
From junction of cuts to first bench............ ...	232,511
" " " river four hundred yards above first bench.........................	187,296
Total excavation from one hundred and ten yards above Steam-mill Bridge to first bench.........	309,876
Total excavation from one hundred and ten yards above Steam-mill Bridge to point four hundred yards above first bench......................	264,661

With the same cross section of thirty feet base, the amount of excavation in the present channel of the river between first bench and the point one hundred and ten yards above Steam-mill Bridge will be:

	Cubic Yards.
Excavation in rock on the three reefs.......	13,363
" " loose earth........................	10,641
Total excavation in rock and and loose earth between first bench and one hundred and ten yards above Steam-mill Bridge..........................	24,204

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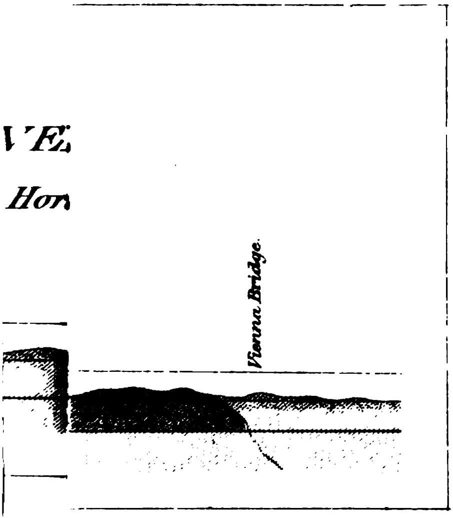

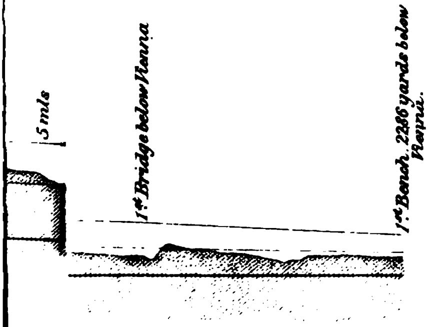

NY
Co 16 & 18 Park Place

This will give the channel from Steam-mill Bridge down, a fall of one foot per mile, while the amount of excavation in the proposed "cut" from the same point one hundred and ten yards above Steam-mill Bridge through by Danville Church to the Pequest at the upper point four hundred yards above first bench will be 264,661 cubic yards, or more than ten times the amount in the river. And I do not think there is any reason to conclude that, in either cut, there will be found less rock than in the river. Yet the "cut" will drain the swamp no deeper than the river in its present channel, if the latter be cut down to the grade line. It would seem then from the above that the cheapest plan to drain the Great Meadows, and the one that will make the drainage thorough, is to cut down the present river bed to the grade represented in the profile.

By reference to the *map* of the Great Meadows, it will be seen that very much cutting can be saved by straightening the Pequest, in many places, between the Steam-mill Bridge and Long Bridge. The area of the swamp is about 5500 acres. The soil is a black muck. The figures on the map denote the depth of the muck down to a sand or gravel bottom. When properly drained, the Great Meadows will be far the most valuable land in that section of country.

The chief expense of this improvement will be in cutting through the rocks at the reefs which may cost $20,000.

APPENDIX C.

Publications of the New Jersey Geological Survey.

Geology of New Jersey, 899 pages large octavo, illustrated by 108 photolithographic engravings and woodcuts, and six mine maps; and accompanied by a portfolio containing the following maps, in sheets:

1. Azoic and Paleozoic Formations, including the Iron-ore and limestone districts; colored; scale 2 miles to an inch:
2. Triassic Formation, including the Red Sandstone and Trap-rocks of Central New Jersey; colored; scale, 2 miles to an inch:
3. Cretaceous Formation, including the Greensand Marl Beds; colored; scale, 2 miles to an inch:
4. Tertiary and Recent Formations of Southern New Jersey; colored; scale, 2 miles to an inch:
5. Map of a Group of Iron Mines in Morris county; printed in two colors; scale, 3 inches to 1 mile:
6. Map of the Ringwood Iron Mines; printed in two colors; scale, 8 inches to 1 mile:
7. Map of the Oxford Furnace Iron-ore Veins; colored; scale, 8 inches to 1 mile:
8. Map of the Zinc Mines, Sussex county; colored; scale, 8 inches to 1 mile:

Price of the book and portfolio of maps, $6.50

Geology of New Jersey, as above, without portfolio of maps, but containing a folded and colored map of the State, on a scale of 5 miles to 1 inch. Price $4.00.

Single copies of either of the above maps, colored and in sheets, 50 cents.

Geological Map of New Jersey, on a scale of 2 miles to one inch; colored and mounted on rollers. It gives the Geology of the State the same as Maps 1, 2, 3, 4, in the portfolio, and is essentially these combined in one map. Size 5½ by 7½ feet. Price $8.00 per copy.

The prices are fixed to merely cover the cost of paper, printing and binding; the expenses of the Survey and preparing book and engravings being paid by the State.

These publications can be had from Prof. Geo. H. Cook, State Geologist, New Brunswick, on remitting the price, or through the booksellers.

The books are also kept for sale at these prices by William T. Nicholson, of Trenton; Sampson & Morgan, of New Brunswick; M. R. Dennis & Co., of Newark, and D. Van Nostrand, of New York city.

The work is in the following public libraries, where it can be consulted:

In all the State Libraries; in some other of the large public libraries in different parts of the United States, and in all the public libraries in New Jersey and in the adjacent cities of New York and Philadelphia. It is also in the offices of most of the County Clerks.

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ANNUAL REPORT

7960

OF THE

STATE GEOLOGIST

OF

NEW-JERSEY,

FOR THE YEAR 1871.

NEW-BRUNSWICK, N. J.:
FREDONIAN STEAM BOOK AND JOB PRINTING HOUSE.
1872.

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1872.

GEOLOGICAL SURVEY OF NEW-JERSEY.

BOARD OF MANAGERS.

His Excellency, Theodore F. Randolph, Governor, and *ex-officio* President of the Board.

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STATE GEOLOGIST :

GEO. H. COOK, New-Brunswick.

To His Excellency, THEODORE F. RANDOLPH, *Governor of the State of New-Jersey, and ex-officio President of the Board of Managers of the State Geological Survey.*

Sir:—I have the honor herewith to submit my annual report, on the Geological Survey of the State, for the year 1871.

With much respect,

Your obedient servant,

GEO. H. COOK,

State Geologist.

RUTGERS COLLEGE.
New-Brunswick, Dec. 26, 1871.

REPORT.

THE operations of the Survey have been prosecuted during the past year, both in the field, and in the laboratory and office. The results of the work will appear, in part, in the following pages; while another part consisting of partially finished work upon the iron mines, and on the soils of the State, is reserved until it can be completed, and published in a separate report.

PERSONS EMPLOYED.

The following persons have been engaged in the work during some portion of the year.

PROF. JOHN C. SMOCK, *Assistant Geologist*, has been occupied with investigations on the rocks of the iron-ore region, in examining mines, the methods of finding and opening them, &c. He began work in June, and has been employed for about two-thirds of the time since.

EDWIN H. BOGARDUS, *Chemist*, has been at his duties in the laboratory all the year, except a few weeks, in which he was in the field collecting specimens of rocks, for examination. His work has consisted of the analysis of ores, rocks, soils, and ferfertilizers.

PROF. EDWARD A. BOWSER, *Civil Engineer*, has been employed a portion of the year in surveying the Drowned Lands on the Wallkill in Sussex Co., and preparing his report, map and profiles of the work. He has also surveyed and mapped the lands liable to overflow on the Passaic, Whippany, and Rockaway Rivers, from Little Falls on the Passaic to Chatham on the Passaic, to Whippany and Madison on the Whippany, and to Rockaway Neck on the Rockaway. He has also surveyed the Great Meadows in Warren County, which are liable to overflow with freshets in the Pequest. The two last mentioned surveys have been made in obedience to the "Act to provide for the Drainage of Lands, approved March 8th, 1871," which puts the direction of works of drainage under the charge of the Board of Managers of the Geological Survey, and requires them to make examinations and surveys, on the petition of owners of the wet and flowed lands. He has been employed about three months.

GEO. W. HOWELL, *Civil Engineer*, has surveyed and mapped the wet and flowed lands on the Passaic and Dead Rivers, from Chatham to Millington on the Passaic, and to Liberty Corner on Dead River. He has also made the maps and profiles for the drainage of the Great Meadows, on the Pequest. He was employed for about one month.

PROPOSED PLAN OF WORK FOR THE COMING YEAR.

The time for which provision has been made for the expenses of this survey ends next year. The special works upon drainage, on our natural fertilizers, on soils and agriculture, and on our iron ores and mining, which were proposed at the beginning, can be closed in that time. The surveys and reports upon drainage have probably been made as full as is required at the state expense, and the present report with those of 1869 and 1870 will have put upon record the facts regarding the most important of these works. The report upon iron ores and mining is well advanced—most of the mines have been re-examined, collections and studies of the rock structure of the region have been made, an account and explanation of the mode of searching for iron-ore veins has been prepared, and the work of completing the report is provided for. It is proposed to print and distribute this report separately.

The report upon soils and fertilizers is so far advanced that it can be published in the course of the year. Such a work can never be complete, as long as agriculture is improving, and we have lands to bring into cultivation, and farming resources to develop.

The progress of the survey continually shows new fields in which the fostering care of the State can profitably be employed to aid individual effort in developing our mineral, manufacturing and agricultural wealth. A better map of our mining districts is much needed. One that would exhibit the topography of the country, show the inequalities of the surface, the mountains, hills, ridges, valleys, &c., would be of great service to the iron industry of the state. It would give direction and accuracy to studies on the geological structure of the region, to mining explorations, to manufacturing enterprises using water-power, and to agriculture. Such a map was made of some sixty or seventy square miles about Dover. It was first drawn on a scale of six inches to a mile, but was afterwards engraved on a scale of three inches. It is much liked by all who have had occasion to use it, and if a similar one could be made of the whole iron-ore region of the state it would be useful, and meet a want which is felt by many. The United States Coast Survey stations would furnish a basis upon which the triangulation could be extended so as to include any desired area in its net work, and give the required accuracy without resort to expensive measurements of a new base line, or to tedious astronomical observations to determine latitudes and longitudes. The construction of such a map involves both money and time. I would respectfully submit whether it is not expedient to inaugurate such a work the coming year, laying out the plan, ascertaining carefully the amount and kind of work to be done, and making proper estimates of its annual cost, the time required for its completion, and the expense of publication.

PUBLICATIONS OF THE SURVEY.

There is a moderate call for the "Geology of New-Jersey," and also for the maps. They have been supplied to all libraries within the state, as far as these have been ascertained. The copies of the Annual Report have been much called for, and they have been distributed more extensively than ever before. The letters of inquiry regarding geological, mineral, agricultural, and other scientific and industrial matters, are very numerous, and occupy much time in answering. As far as possible, these have been attended to.

There have been two applications to the Board during the year for permission to use the geographic, topographic and other material collected by the Survey. The Board, considering that the interests of the state were best subserved by favoring enterprises which have for their object the publication of our resources, passed the following resolution. "That the State Geologist be authorized to allow the publishers of maps and geographical books to make such use of the material under his control, as will in his judgement tend to diffuse a knowledge of the resources of the state, provided that no exclusive privilege be granted to any publisher; and the maps and printed matter in such publications shall first be submitted to the State Geologist, and be approved by him before publication." Under this authority, Messrs. Beers, Comstock and Kline, of Newark, map publishers, have been allowed the use of material from the Survey, in preparing a new atlas of the state. And it is fair to presume that our citizens will get a better atlas for the price paid than they could have got without the use of this material.

DRAINAGE LAW.

At the last session of the Legislature, a law was passed entitled "An act to provide for the drainage of lands,"* in which "the Board of Managers of the Geological Survey, on the application of at least five owners of separate lots of land included in any tract of land in this state, which is subject to overflow from freshets, or which is usually in a low, marshy, boggy or wet condition, shall be and hereby are authorized and empowered to examine such tract, and if they shall deem it for the interest of the public, and of the land-owners to be affected thereby, they are further authorized, from time to time, to make surveys of any such tract or tracts of land, and to decide upon and adopt a system of drainage for draining the same, and to cause maps of the same, together with the plans of drainage by them adopted, to be made ; and for this purpose they shall be authorized to call in the assistance of the State Geologist, and such other persons as they may deem expedient ; and when they shall have completed their said surveys, maps and plans, they shall make a written or printed report of the same to the Supreme Court of this state ; and thereupon it shall be the duty of the said Court, at the same or next stated term thereof, or as soon as can conveniently be done, upon reasonable notice given to that effect, and published in a newspaper circulating in the county where such tract of lowlands is situate, to appoint three commissioners (not interested in the lands to be drained) to superintend and carry out the drainage of any particular tract or tracts aforesaid, whose duty it shall be to carry out and execute the system of drainage which may thus have been adopted and reported by the said Board of Managers, in reference to said particular tract or tracts ; provided, that if, at the time fixed for such appointment of commissioners, it shall appear to the Court by the written remonstrance of the owners of a majority of the said low and wet lands, duly authenticated by affidavit, that they are opposed to the drainage thereof at the common expense, then the said Court shall not appoint such commissioners as is directed in this section." Other sections prescribe the mode of proceeding to execute the work, to assess and collect money to pay the expense, to compensate for damages, and to perform all acts necessary to carry out the contemplated work of drainage.

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*Laws of New-Jersey, 1871; Chap. 132, p. 25.

Under this act the " owners of lands subject to overflow, bordering the Passaic River between Chatham and Little Falls," applied to the Board of Managers to examine said lands, determine upon a system of drainage for the same, and to take such legal steps as may be necessary to effect the object desired with the least delay. A meeting of the managers was held, a committee appointed to examine the lands, and if judged expedient to prepare maps and plans for the drainage, and report to the Board. The committee made the examination, directed surveys, maps and plans of the proposed drainage to be prepared, and when these were done, submitted them to the Board with their report. Their report was accepted, and ordered to be presented to the Supreme Court for the appointment of commissioners. The report and maps were presented to the Supreme Court in June last, and notice of the application was published in the newspapers of Essex, Morris and Passaic counties for eight weeks preceding the November term of the Court. The commissioners have not yet been appointed.

A like application was made by the owners of wet and overflowed lands on the Passaic River, between Chatham and Millington, which was received by the Board of Managers, and acted upon in the same manner with the preceding. The maps plans and report were presented to the Supreme Court in June, and public notice of the application was given for two months preceding the November term of the Supreme Court, in the newspapers of Essex, Morris, Somerset and Union. The result of the application is not yet announced.

An application has been made to the Board by the owners of wet and boggy land in the Great Meadows, on the Pequest, in Warren County, for the examination, and if judged proper, for a plan of drainage of said meadows; and that the necessary action be taken to carry out the plan under the Drainage Law. The map, plan and report upon the same are before the Board for their final action this day.*

The execution of these works of drainage would reclaim a large amount of rich and valuable land, would do much to drive away chills and fever, which are now quite too common, and would greatly help the attractiveness of important parts of the State. At the same time, the pecuniary benefits arising from the increased value of the lands, will be secured to the landowners. The plans presented by the Board, as well as the provisions of the law, are arranged so as to keep down the expenses as low as is consistent with the proper and thorough execution of the work; and the powers of the commissioners will enable them to carry out the work without burdensome taxation of the land-holders.

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*The map and plan are filed in the Office of the Clerk of the Supreme Court, and the Board ordered the application to be made at the February Term.

DROWNED LANDS OF THE WALLKILL.

The valley of the Wallkill, from Hamburg in Sussex County, almost to Goshen in Orange County, New York, is largely occupied by a tract of swamp and marshy grounds, known as the Drowned Lands. The obstruction which stops the flow of the stream and causes these lands to form, is in the State of New York, and the largest body of swamp and marsh is in that State; but the portion in our state is a large one—not less than ten thousand acres* in Sussex County being subject to overflow whenever there is a freshet in the Wallkill, and the current in the stream is so sluggish that the water in a single freshet remains for many days upon these lands, effectually preventing cultivation, and rendering the natural and wild growth almost worthless. The importance of reclaiming these lands has induced me to have them surveyed, and proper levels taken so as to find out the nature of the obstructions to the flow of the stream, their location and extent.

Prof. Edward A. Bowser has made the examinations, and he finds the chief obstruction to be in a heavy deposit of drift-earth and boulders, and perhaps some slate rock in the lower part, which fills the valley at Denton and Hampton, three miles and a half west of Goshen, in Orange County. The Wallkill found a passage over this bank, but had not the force to wear it away, and the water remained dammed up in a pond, filling the valley for twenty miles south, and in some places spreading out to a width of four miles. In passing over this bank the water had a fall of twenty-four feet in a distance of two miles. At an early period, dams were built at Hampton to utilize this fall, and two mills were erected. The property in these mills has operated as a hindrance to any efforts for lowering the bed of the stream, or carrying out any plan for draining the Drowned Lands. About forty years ago a very vigorous effort was made to improve the drainage, and a ditch or *canal* was cut across from the stream at the lower end of the Drowned Lands, the location of which was about a half mile east of the old channel, and entered the original bed three miles below, shortening the distance about a half mile. The water all runs in the new channel now, and its surface at the lower end of the Drowned Lands is considerably lower than the bottom of the old bed of the stream. This has done much to improve these lands, but it is by no means all that is needed. They are still flooded after heavy rains, and the current of the stream is scarcely perceptible in thirty miles or more of its tortuous course. In the freshet on the first of September, 1871, the fall in the whole distance from Denton to Ogden's Bridge, which by the course of the stream is thirty-five miles, was only seven and a half feet.

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* The whole area of these lands is 25,600 acres of which 15,600 acres are in Orange County.

It would be easy to deepen the canal seven or eight feet. A very moderate expense in cutting off bends in the stream would shorten its course several miles, and the removal of a few bars in the channel would give a uniform and lively current to the Wallkill through the whole length of the Drowned Lands.

New-Jersey is largely interested in having this improvement carried out. And I have no doubt that any active effort on the part of the owners of the flooded lands in Sussex, would meet a hearty response from those interested, in Orange County, and that together they could carry it to a thorough successful end.

The value of these lands where they have been successfully drained, can hardly be over estimated. In the vicinity of Chester, Orange County, a considerable tract is reclaimed and cultivated. Onions have been a specially successful crop ; a thousand dollars worth having, in many cases, been taken from a single acre of this black ground. Near Florida, in the same county, I saw a field of this kind, from which the owner assured me he had taken a hundred and fifty bushels of ears of corn per acre, for fifteen years in succession. Potatoes, also, yield enormous crops in this soil. For meadows and pasturage it is all admirably adapted. The carrying out of this work

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would change an unsightly waste into a field of rural beauty and riches.

The report of Prof. Bowser, with his map and profiles, is presented here.

Prof. Bowser's Report of the Levels and Soundings taken on the Wallkill River and its branches, the Pochunk and Wawayanda Creeks, in Sussex County, N. J., and Orange County, N. Y.

A bench, called "first bench," was made on a large maple tree, on the right bank of the Wallkill, and on the left bank of the "canal," at their junction, or "outlet" of the canal, about 800 yards below Hampton. The datum plane was assumed 10 feet under this bench. A line of levels was run from this bench up the Wallkill to Lawrence's Bridge, distant in a right line about 20 miles, and about 37 miles by following the channel; and also up the Pochunk Creek to the second bridge above the mouth of the Wawayanda Creek; and up the Wawayanda to the second bridge; and benches were located at all the bridges and at intermediate points. The heights along the surface of the river were determined by leveling from these benches. The heights along the bottom were determined by sounding in the channel, and subtracting the depths from the heights of the surface. The heights of the points, both along the surface and the bottom of the river, were measured from the datum plane 10 feet beneath the first bench.

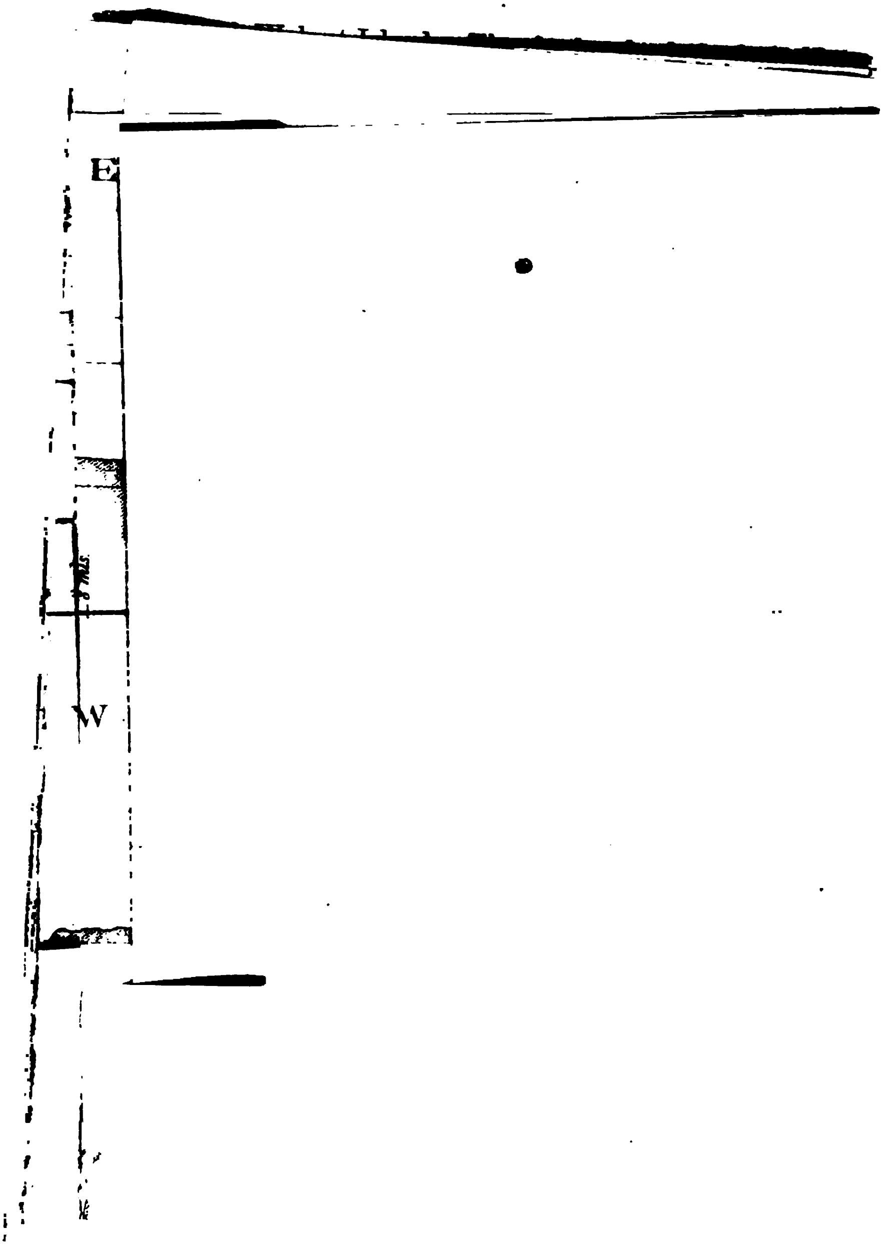
By examining the profile, it will be seen that the bed of the river, from the first bench up to the lower end of the Drowned

Lands, has a rise of 24.6 feet, while the rise from the first bench to the upper end of the canal—inlet of the canal—is but 14 8-10 feet, making the bed of the river at the latter place 9 8-10 feet *lower* than it is at the lower end of the Drowned Lands in the old channel of the river.

The bed of the river at the lower dam is 10 7-10 feet, and at the upper dam, just below the railroad bridge, it is 14½ feet higher than it is at the first bench. Although the bed of the river from the second dam to the lower end of the Drowned Lands rises 10 1-10 feet, yet owing to the *fall* of 9 8-10 feet from the latter place to the inlet, the rise from the second dam to the inlet is only 8-10 of a foot, and from the first dam to the inlet it is only 4 1-10 feet. The top of the lower dam is 4-10 of a foot, and that of the second dam 6 7-10 feet higher than the bed of the river at the inlet.

The rise in the bed of the river, from the inlet to Pellett's Island bridge, is 3½ feet, while from the latter up to Willcox's bridge, distant 12½ miles by the river, the rise is only 1 2-10 feet. The bed of the river at Black Walnut Island is 3½ feet *higher* than it is at Willcox's bridge. The bed of the river at Kimberg Point bridge is 4 3-10 feet *lower* than at Willcox's bridge, and 7 8-10 feet *lower* than at Black Walnut Island, while just above the State Line, it is 3 7-10 feet higher than at Willcox's, or on a level with the bed at Black Walnut Island. The bed at Bessett's bridge, distant ten miles from Willcox's by the channel, is on a level with that at Willcox's bridge, or 3 7-10 feet *lower* than at Black Walnut Island, while from Bessett's to Ogden's bridge, distant nine miles following the channel, owing to the increased shallowness of the river, the rise is 11 7-10 feet, making a rise of 8 feet from Black Walnut Island to Ogden's bridge, or 16 1-5 feet from the inlet to Ogden's. The rise from Ogden's to Lawrence's bridge is 2 7-10 feet.

The profile of the Pochunk Creek shows that its bed at the mouth is 7 4-5 feet *lower* than the bed of the Wallkill at Black Walnut Island, and that its bed at the Neck bridge, Garner's Island bridge and the Pochunk bridge is 1 4-5 feet, 9-10 feet, and 3 1-5 feet, respectively, higher than the bed of the Wall-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kill at Black Walnut Island. The rise in the bed, from the Pochunk bridge to Martin's bridge, is 6 7-10 feet, from Martin's to the first bridge above the mouth of the Wawayanda Creek it is 4 1-5 feet, and from the latter bridge to the second bridge above the mouth of the Wawayanda the rise is 2 9-10 feet.

The rise of the bed on the Wawayanda Creek, from the mouth to Edsall's bridge is 3 3-10 feet, and from Edsall's to the second bridge the rise is 5 7-10 feet.

The profile of the Canal shows that the rise of its bed is much more uniform than the rise of the bed in the old channel. The rise in the bed from thfirst bench to the railroad bridge is 2 1-5 feet; from the railroad bridge to Wheeler's bridge it is 8 3-10 feet; and from Wheeler's bridge to the inlet the rise is 4 3-10 feet, and very uniform, excepting a reef about 600 yards above Wheeler's bridge, which is 2 7-10 feet *higher* than the bed at the inlet. The top of the old dam, 800 yards below Wheeler's bridge, is 28 3-10 feet above the bed of the river at the first bench, or 3 7-10 feet higher than the bed of the old channel at the lower end of the Drowned Lands.

The rise of the water surface on August 16, 1871, from the inlet to Willcox's bridge, 12½ miles, was 6½ feet, and from Willcox's bridge to Ogden's bridge, 9 miles, it was 3 3-10 feet, making a rise of 9 4-5 feet from the inlet to Ogden's bridge, distant 21½ miles. Though it was a very dry time, the water from Black Walnut Island up to Ogden's was on a level with the top of the ground. On September 1st, when there had been considerable rain, the rise of the water surface from the inlet to Willcox's bridge was 7 1-5 feet. Much of this rise was owing to the obstruction at Black Walnut Island, where the water runs over a point of the upland. The surface rise from Willcox's to Ogden's was 1½ feet, and from Ogden's to Lawrence's it was 3 7-10 feet. The water during this week was from 2 to 5 feet deep on the "Drowned Lands." The rise of the water surface, on the Pochunk, during this time, from its mouth to the Pochunk bridge, was 1 foot; from the Pochunk bridge to Martin's bridge it was 3 7-10 feet; and from Martin's to the second bridge above the mouth of the Wawayanda it was 5 1-10 feet, the water standing 3 and 4 feet deep on the meadow. The rise of the water surface, on the Wawayanda, during the same time, from its mouth to Edsall's bridge was 3 3-10 feet, and from Edsall's to the second bridge on the Wawayanda it was 5 7-10 feet. The country from the lower end of the Drowned Lands to Lawrence's bridge, and on the Pochunk to the second bridge above the mouth of the Wawayanda, was covered with water, in many places 5 feet deep. This water remained upon the land over two weeks.

A fall of 8 inches per mile would give the Wallkill a velocity of about 1½ feet per second. If the river from Ogden's bridge down to the first bench be shortened to 30 miles, which can very easily be done by cutting off some bends, 8 inches per mile would give a fall of 20 feet from Ogden's down to the first bench. Had this been the fall of the Wallkill in the first week of September, and the grade at Ogden's bridge 4 feet below its present bed, which is now entirely too shallow, the water could scarcely have remained above its banks for more than two days.

The grade line on the profile represents this new bed. It begins at Ogden's bridge, 4 feet below the present bed, and falls 6 9-10 inches per mile, following the present channel as it is represented in the profile; or, if the channel from Ogden's bridge to the first bench be reduced to 30 miles, the grade will be 8 inches per mile, giving in either case a fall of 20 feet from Ogden's bridge down to the first bench.

By examining the profile, it will be seen where the grade runs *below* the present bed, and where it runs *above* it. At Bessett's bridge it runs *above* the bed, while 400 yards below the bridge it runs *under* it 6 feet. At Kimberg's Point bridge the grade is again above the bed, while 500 yards below, it is 8 feet beneath it. At Stewart's landing the grade is 10 feet beneath the bed. At Willcox's bridge it is 3½ feet beneath the bed. At lower end of Willcox's Island it is 10½ feet beneath the bed. At the mouth of the Pochunk it is 2½ feet beneath the bed. At the upper end of Black Walnut Island it is 9½ feet beneath the bed. At the lower end, 7 feet beneath. It reaches Pellett's Island bridge 9 feet under the bed, and the inlet of the canal 6 feet under the bed. Following down the old channel we see that the grade reaches the lower end of the Drowned Lands 16½ feet beneath the present bed, the railroad bridge 11½ feet, the second dam 7 feet, and the first dam 3½ feet beneath the present bed. It reaches the first bench 7 4-5 feet above the present bed. Following the canal, whose bed is much more uniform, the grade reaches the reef 9 feet, Wheeler's bridge 3 feet, and the dam below Wheeler's bridge 1 foot below the present bed of the canal. The cutting in the old channel, the profile shows, greatly exceeds the cutting in the canal.

The Pochunk Creek, being a smaller stream, requires a greater fall. At the second bridge above the mouth of the Wawayanda Creek, the Pochunk at present is entirely too shallow. Its bed here should be cut down 6 feet, leaving a fall of 19½ feet from this bridge to the mouth of the Pochunk, distant 11 miles, or 1 4-5 feet per mile. This grade, as the profile shows, reaches the first bridge above the mouth of the Wawayanda 5½ feet, Martin's bridge 4 feet, the Pochunk bridge 4½ feet, Garner's Island bridge 5 feet, and the Neck bridge 7 feet below the present bed of the channel. It reaches the mouth of the Pochunk 2½ feet beneath the present bed, or on a level with the grade on the Wallkill River.

The Map accompanying this report shows the extent of the Drowned Lands, the exceedingly crooked channel of the Wallkill and the Pochunk, and the nature of the surface material, whether black muck alone or mixed with mud (blue clay). The figures on the map denote the depth in feet of the surface material down to the hard bottom, which is sand or gravel. The material for drawing the map of that part of the Drowned Lands which lies in Orange County, was obtained from A. S. Murray, Esq., of Goshen, who very kindly lent me a map of these lands, that was made several years ago, when there was an attempt made to drain them. The material for making the map of that portion of the Drowned Lands that lies in Sussex County was obtained by traversing the shore line during high water. The depth of the surface material was ascertained by running an iron rod down to the solid bottom. Wherever it was muck alone, the ground was very soft, the rod running down easily. Where there was considerable clay—which was generally near the banks of the Wallkill and the Pochunk, and especially near streams running into these channels—the ground was very firm, the rod running down with difficulty. The nature of the surface material in Sussex County, and also of that portion of the land in Orange County that produces only wild grass, is similar to that in Orange County that is under cultivation, and that produces as fine crops as are to be seen anywhere in the country. There is this difference, however: the surface material in Sussex County, above Bessett's bridge, is not so deep as it is lower down in Orange County. The number of acres of Drowned Lands in Orange County, (by Murray's Map), 15,579; the number of acres in Sussex, 10,000; total number of acres of the Drowned Lands in Orange County and in Sussex, on the Wallkill River, and the Pochunk and Wawayanda Creek, 25,579.

As the amount of cutting in the canal will be far less than in the old channel, it will be economy to carry the water down the canal, where it is running at present. If one of the mills below Hampton could be saved, it would be very desirable to carry the water down the old channel. But as the grade runs 3½ feet *beneath* the bed of the river at the lower dam, there will be no possibility of saving a mill. It seems, therefore, that there can be no object in carrying the water down the old channel, when it can be taken down the canal with *far less expense*.

AGRICULTURE AND POPULATION.

The United States census of 1870, though only partially published as yet, gives some information of much interest to Jerseymen. The population of the United States and of the State of New-Jersey is given in the following table, for every ten years, beginning with 1790. The table also shows the percentage of increase for each ten years:

	Population of United States.	Percentage of increase.	Population of N. Jersey.	Percentage of increase.
1790......	3,929,827		184,193	
1800......	5,305,937	35.02	211,949	15.10
1810......	7,239,814	36.45	245,555	15.86
1820......	9,638,191	33.13	277,426	13.04
1830......	12,866,020	33.49	320,823	15.58
1840......	17,069,453	32.67	373,306	16.36
1850......	23,191,876	35.87	489,555	31.14
1860......	31,443,321	35.58	672,035	37.27
1870......	38,998,753	24.03	906,096	34.83

It will be seen that there has been a very uniform increase in the population of the United States up to the last ten years, when the destructive civil war interfered to check our rapid growth, and diminished the aggregate by probably three million persons.

Our own state has had a much more irregular growth. For fifty years after 1790, the percentage of increase was less than half that of the whole country, owing probably to the large emigration to the newer States. Since then, however, the growth has been much more rapid—for twenty years about equal to that of the whole country, and for the last ten years considerably greater. Our growth was checked by the war, the state census of 1865 showing a population of 773,700, and an increase of 15.14 per cent. in five years, while the percentage of increase for the last five years is 19.70, a more rapid growth than it has ever had before.

The increase of population is not uniform throughout all parts of the state, as appears in the following list of counties with the population of each for every ten years from 1790 to 1870, with the ratio of increase for the last ten years. The arrangement of counties is geographical, so as to bring those counties which have been set off since 1790 next those from which they were taken :

POPULATION OF NEW-JERSEY AT DIFFERENT PERIODS.

COUNTIES.	1790.	1800.	1810.	1820.	1830.	1840.	1850.	1860.	1870.	Pr cent. increase past (10 years.)
Bergen	12,601	15,956	16,603	18,178	22,412	13,223	14,725	21,618	30,122	39.34
Passaic	-------	-------	-------	-------	-------	16,734	22,569	29,013	46,416	59.98
Hudson	-------	-------	-------	-------	-------	9,483	21,822	62,717	129,067	105.79
Essex	17,785	22,269	25,984	30,793	41,911	44,621	73,950	98,877	143,839	45.47
Union	-------	-------	-------	-------	-------	-------	-------	27,780	41,859	50.68
Morris	16,216	17,750	21,828	21,368	23,666	25,844	30,158	34,677	43,137	24.40
Sussex	19.500	22,534	25,549	32,752	20,346	21,770	22,989	23,846	23,168	—2.84
Warren	-------	-------	-------	-------	18,627	20,366	22,358	28,433	34,336	20.76
Hunterdon	20,153	21,261	24,556	28,604	31,060	24,787	28,990	33,654	36,963	9.83
Mercer	-------	-------	-------	-------	-------	21,502	27,992	37,419	46,386	23.96
Somerset	12,296	12,815	14,725	16,506	17,689	17,455	19,692	22,057	23,510	6.58
Middlesex	15,956	17,890	20,381	21,470	23,157	21,893	28,635	34,812	45,029	29.35
Monmouth	16,918	19,872	22,150	25,038	29,233	32,909	30,313	39,346	46,195	17.41
Ocean	-------	-------	-------	-------	-------	-------	10,032	11,176	13,628	21.94
Burlington	18,095	21,524	24,972	28,882	31,107	32,831	43,203	49,730	53,639	7.86
Camden	-------	-------	-------	-------	-------	-------	25,422	34,457	46,193	34.06
Gloucester	13,363	16,115	19,744	23,089	28,431	25,438	14,655	18,444	21,562	16.90
Atlantic	-------	-------	-------	-------	-------	8,726	8,961	11,786	14,093	19.58
Salem	10,437	11,371	12,761	14,022	14,155	16,024	19,467	22,458	23,940	6.60.
Cumberland	8,248	9,529	12,670	12,668	14,093	14,374	17,189	22,605	34,665	53.35
Cape May	2,571	3,066	3,632	4,265	4,936	5,324	6,433	7,130	8,349	17.09
Total	184,193	211,949	245,555	277,426	320,823	373,306	489,555	672,035	906,096	34.83

The chief increase in population has been in the cities and towns near New York, and consists largely of manufacturers, artisans, and persons doing business in that city. There is, however, a large addition of persons in easy circumstances who have come here to get the climatic, social and educational advantages of New-Jersey. It is worthy of remark that the counties which are purely agricultural, and are well improved throughout, have increased very little in the last ten years. Sussex, our best dairy county, has lost more than two per cent. Salem and Somerset, models of thrifty and productive farming districts, have gained but little more than six per cent.; Burlington and Hunterdon, our largest and wealthiest farming counties, only about eight and ten per cent. respectively. And of several others the increase is in the towns and not in the country. In fact, wherever the land is cleared and in good cultivation, it needs, with the modern implements, fewer hands to till the soil than it did forty years ago. In many sections this loss of population is very evident, at the same time that the farms are made to produce double, and in many cases four times as much as they formerly did.

There has been a considerable increase in the population of those counties which contain a large area of uncleared land. The wants of our first settlers required that they should clear and till land that would produce crops at once, and without manure; and such were the only lands cultivated in the early settlement of our State. All lands which did not possess this degree of available fertility were considered to be barren and valueless. A large area in New-Jersey especially in the southeast parts, came under this condemnation, and were held in disrepute till very recently. In the counties of Cape May, Cumberland, Salem, Gloucester, Camden, Atlantic, Burlington, Ocean, Monmouth and Middlesex there were in 1860, 734,561 acres of land of this class, and still covered with a forest of oak and yellow pine. It is one of the discoveries of modern farming that such lands can be profitably tilled. And there has been a considerable addition to our population in the new settlements in various parts of these counties; Cumberland and Atlantic in particular have increased largely in this way.

There is a continued advance in the Agriculture of the State. The area of improved land is growing larger, the land is better cultivated, more fertilizers are used, and larger and better paying crops are raised. This improvement is chiefly due to our location near New-York and Philadelphia, the best markets on our continent, and to our large manufacturing and mining population, which makes a ready home market for our products. But it is partly due to the real capabilities of the soil for raising crops ; which heretofore, and under an exhausting system of tillage, have been greatly underrated, but which, with an improved system of tillage, the judicious use of manures, and restorative crops, are proving their real worth. The statistics of farm lands and their value in our state will be more plainly exhibited by a comparison with those in the states of Connecticut, New-York, Pennsylvania and Delaware ; these states being nearest to us and to the great markets.

	Area in Acres.	Per centage of Land in Farms.
Connecticut	2,991,360	79
New-York	30,080,000	74
New-Jersey	4,848,832	62
Pennsylvania	29,440,000	61
Delaware	1,356,800	78

The prices of the farm lands per acre for the years 1850, 1860 and 1870, are given in the following table :

	1850.	1860.	1870
Connecticut	$30.50	$36.00	$52.54
New-York	29.00	38.00	57.36
New-Jersey	43.67	60.40	86.14
Pennsylvania	27.33	39.00	58.00
Delaware	19.75	31.00	44.39

From this, it appears that the value of our farm lands, by the acre, is much greater than in the neighboring states, and that it is still increasing as rapidly as ever.

In farm products, the comparison is equally favorable, as appears by the following table, which is also compiled from the census returns.

	Connecticut.	New-York.	New-Jersey.	Pennsylvania.	Delaware.
Bushels of Grain and Corn........	3,206,773	77,751,088	15,985,688	97,992,934	4,473,625
" Potatoes................	2,790,761	28,558,199	6,256,223	13,020,939	448,033
Value of Orchard Products.........	$535,954	8,347,417	1,295,282	4,208,094	1,226,893
" Market Garden Products....	$599,719	3,432,354	2,978,250	1,810,016	198,075
" Slaughtered Animals.........	$4,881,858	28,225,720	6,982,162	28,412,903	997,403
Est'ed value of all Farm Products..	$26,482,150	253,526,153	42,725,198	189,946,027	8,171,667
Value of all Live Stock...........	$17,545,038	175,882,712	21,443,463	115,647,075	4,257,223

The comparison between these different states can easily be made when it is considered that the land in farms in Connecticut is five-sixth as much as in New-Jersey; in New-York, seven times as much; in Pennsylvania. six times; and in Delaware, one-third as much.

A Comparison of the Agricultural Statistics of New-Jersey for Thirty Years.

FROM THE U. S. CENSUS REPORTS.

		1840.	1850.	1860.	1870.
ACRES OF LAND } Improved	Acres	....	1,767,991	1,944 441	1,976,474
ACRES OF LAND } Woodland and other unimproved	"	....	984,955	1,039,084	1,013,037
PRESENT CASH VALUE } Of Farms	Dollars	....	120.237,511	180,250,338	257,523.376
PRESENT CASH VALUE } Of farming impl'nts & machin'y	"	....	4,425,503	5,746,567	7,887,991
Orchard Products	"	464,006	607,268	429,402	1,295,282
Produce of Market Gardens	"	249,613	475,242	1,54[illegible],695	2,978,250
Value of Animals Slaughtered or sold for Slaughter	"	....	2,638,555	4,120,276	6,982,162
Wool	Pounds	397,207	375.396	349,250	336,609
Butter	"	$1.328,032	9,478.210	10,714.447	8,266,023
Cheese	"	....	365,726	182,172	38.229
Milk Sold	Gallons	....	....	....	5,373,323
Value of all Live Stock	Dollars	....	10,679,291	16,134.693	21,443.463
Horses	Number	....	63,955	79,707	79,708
Mules and Asses	"	70,502	4,089	6.362	8,853
Milch Cows	"	....	118,736	138,818	133.331
Working Oxen	"	220,202	12,070	10.067	3,830
Other Cattle	"	....	80,455	89,909	60.327
Sheep	"	219,285	160,488	135,228	120,067
Swine	"	261 443	250,370	236,089	142,563
WHEAT } Spring	Bushels	....	....	....	2,099
WHEAT } Winter	"	774.203	1,601 190	1,[illegible]63 218	2,299,334
Rye	"	1,665,620	1,255.578	1,439,497	566,775
Indian Corn	"	4,361,975	8,759,704	9,723.336	8,745,384
Oats	"	3,083,524	3,378.063	4,539,132	4,009,830
Barley	"	12.501	6.492	24,915	8,283
Buckwheat	"	846,117	878.934	877.386	353.983
SEED } Clover	"	....	28,280	39.205	26,306
SEED } Grass	"	....	63,051	85.408	72.401
Hay	Tons	334,861	435,950	508,726	521,975
Peas and Beans	Bushels	....	14,174	27,674	56.221
Irish Potatoes	"	2.072,060	3,207,236	4,171.690	4,705,439
Sweet Potatoes	"	....	508,015	1,034,832	1,550,784
Hops	Pounds	4,531	2,133	3,722	19,033
Flax	"	....	182.005	48,651	234 061
Flax Seed	Bushels	....	16,525,	8,211	6,095
Sorghum Molasses	Gallons	....	....	306	17,424
Tobacco	Pounds	1,922	319	149,485	40,871

A comparison of the census statistics of New-Jersey of 1840, 1850, 1860, and 1870, shows the direction in which its agriculture has developed. The area of cleared lands has increased but little. The value of farm lands has doubled.

The increased sales of farm produce, have been in orchard and market garden products, and in the value of animals slaughtered or sold for slaughter, There is a large increase in the quantity of potatoes raised. No statistics of other root crops have yet been collected, though turnips, in particular, are raised in large quantities for feeding stock.

More wheat is raised, and less rye than there was thirty years ago. The amount of Indian corn raised is double what it was in 1840.

In live stock it is remarkable that there is no increase in number, though there is a very large increase in value. Nothing shows this better than the sheep, which only number about half what they did in 1840, while the amount of wool has fallen off but little. There is a diminution in the number of working oxen, and an increase in the number of mules.

The changes are such as are called for by the peculiarities and advantages of our location. This will be more clearly seen, when the great development of our railroad system, and the consequent increase in marketing facilities, are considered.

According to the United States census of 1850 there were at that time 206 miles of railroad in operation in New-Jersey. In 1860 the number of miles was 560. The returns for 1870 are not at hand, but at the end of 1871 there were 1,110 miles in running order, an increase at the rate of 100 per cent. in eleven years.

At the beginning of the Geological Survey in 1854, and before the new settlements and improvements in the southern part of the state began, the total length of the railroad lines was 408 miles. Of this 78 miles only were in that half of the state south and southeast of the Camden and Amboy Railroad. In 1864, the date of the revival of the Survey, the length of railroad had increased to 704 miles, and that of the southern portion of the state to 305 miles. At the close of 1871 this length had still further increased to 405 miles. The ratio of railroad length to area is 1:6.82, *i. e.*, one mile of road to each 6.82 square miles of territory, so that if uniformly distributed no person in the state would be two miles from a railroad. And as it is, there are very few people in the state who cannot go to New-York or Philadelphia, transact business and return the same day.

In this condition of the agricultural resources of New-Jersey and its advantages for profitable development, there is a sufficient reason for the increased attention which is given to farming in all parts of the state.

The improvement so far has been mainly by enriching the land already cleared, and tilling and cultivating it more thoroughly. The marked success which has attended this is a warrant for bringing the still uncleared lands into cultivation. There are now almost a million acres of such lands in southern New-Jersey, which can be successfully brought into farms. Vineland, with its 10,000 inhabitants, Hammonton, Egg Harbor City, Bricksburg, Manchester and many smaller settlements, are on ground, that only ten or fifteen years ago were uncleared—and now they have become self-supporting—raising good crops of corn, wheat, clover, potatoes and other staple crops, and fruits in abundance, both for family and for market purposes.

Experience shows that this light land can be cheaply and easily cleared. It needs fertilizing for the first crop, but this is compensated by the cheaper tillage, warmer soil and fewer delays from either extremely wet or dry weather. The mildness and salubrity of the climate, too, are attractive to those who have experienced the rigors of a northern winter.

Immense deposits of peat are found in all parts, and the railroads give ready access to the marl beds. No better fertilizers than these can be found for supplementing the stores of the barn-yard, and there is no cheaper or more lasting fertilizer than the green-sand marl, which exists in inexhaustible quantities.

These uncleared lands constitute the largest body of undeveloped wealth in the state, and they offer a most inviting field for those who wish to get cheap farms and homes for themselves, and at the same time to retain the advantages which come from proximity to the great business centres of the country. Wild land can be got at from $5 to $25 an acre, according to its nearness to roads, railroads and settlements. The wood upon it is in many cases worth all the land costs. This is cut off, in the early summer, if possible, the brush is left scattered all over the ground, except a strip 10 or 15 feet wide all around the field. From this strip the brush and leaves are raked off and several furrows are plowed in it, so as to stop fire from getting into the adjoining lands. When dry the brush is fired on the windward side, and in a few minutes the fire sweeps over the whole ground, burning leaves, brush and everything, except some of the larger sticks. This costs not more than a dollar an acre. The ground is then plowed and harrowed, at a cost of $6, and dressed with 40 or 50 bushels of slaked lime per acre, at a cost of $5. The ground may then be sown with rye, and in the following spring with clover seed. The crop of rye will amount to 10 or 12 bushels an acre, and the clover will grow for two years, giving a crop of perhaps a ton an acre, each year.

Some farmers after plowing and liming the ground prefer to plant to potatoes in the spring, dressing them with 400 pounds of super-phosphate of lime, or 5 tons of marl, to the acre. An average crop of potatoes raised in this way is 50 bushels an acre. A crop of wheat or rye follows the potatoes. It is dressed with barn-yard manure, compost, or any good fertilizer that can be got. The quantity of wheat or rye will not be more than 10 or 12 bushels an acre. The clover sown in the wheat is a light crop, but it grows, and is the beginning of the improvement of the land.

After the land has been in clover two years, it is plowed up and planted to corn, of which it will yield a crop of 40 bushels an acre, without other fertilizer than the sod. Most of the stumps will plow out by this time. The corn may then be followed by oats or potatoes, and that crop by wheat, using such fertilizers as the farm will afford, and buying marl, super-phosphates, other purchased fertilizers, or gathering muck, marsh-mud, fish, sea-weed, &c., for composts, as the location will permit.

By the third rotation in this way, wheat may be brought to an average of 20 bushels an acre, corn to 70 bushels, and hay to 3 tons, while the cost of tillage is but little more than half what it is on heavy soils.

Iron Ores and Mining.

MAGNETIC IRON ORE.

In the Final Report, made in 1868, the "*list of mines of magnetic iron ore*" included 115 separate mines and groups of mines. The list as corrected in the autumn of 1871, contains 161 mines and localities, at which mining operations have been undertaken in their examination or further development—an increase of 46 during the past three years. This additional number is mainly due to quite recent explorations in Warren and Sussex Counties. In Morris County there has been little discovery outside of the large mines already in opertion. Within the limits of these there is, of course, much change and discovery as they are more and more extensively opened. But the number of localities at which ore is mined is less than it was a few years ago. The product is considerably greater, showing that the mines are more vigorously worked than at any previous period, and also that their capacity is not lessened as they get deeper. Several comparatively new openings have been given up, and some of the older mines appear to be worked out. The greater portion of the ore comes from about thirty mines and groups of mines. And these furnished nearly the same relative proportion of it three years ago. The remaining 131 localities consist of new openings, mines that are idle, and those that are yielding small amounts of ore. Many of them must be regarded as still in the nature of explorations—*undeveloped.* Of the mines not working, many are narrow *veins* and strings of ore ; in some there is too much rock, rendering the extraction of the ore unprofitable ; others are too far from easy and cheap communication, lines of railroad or canal ; a few are held by owners not in need of an additional supply of ore ; and a very few are idle for reasons known only to the business management.

In Hunterdon County nearly all of the iron ore mined comes from the Bethlehem and High Bridge mines. Some work in prospecting has been done near Lebanon and at various points on the Musconetcong Mountain, but the product of these discoveries has been inconsiderable.

In Warren County there have been several new openings made on the mountain range running northeast from Washington to the Sussex County line. Ore has been discovered in workable quantities at several points on the subordinate ridges of Jenny Jump Mountain. The most extensively worked of these new mines is that of the Pequest Mining Company, about two miles northeast of Oxford Furnace.

On Schooley's mountain, in Morris County, there are a few quite recent discoveries of ore, but they are not yet sufficiently explored to determine their probable value. Near Chester, three mines have been opened since 1868. Northeast of these, the mining operations, with few exceptions, are confined to the older localities.

In Sussex and Passaic counties the construction of the Midland Railroad has given a fresh impetus to searches for ore, and brought to light some outcrops that are quite encouraging. The completion of this road will no doubt lead to other discoveries, and to the further development of ore beds now known. Hitherto these have been almost valueless, in consequence of the cost of carting the ore several miles over rough roads to railroad and canal lines.

During the past year there have been some interesting discoveries of iron ore in the north eastern part of Somerset County—from two to three miles west of Bernardsville, but the diggings are still too limited in extent to speak with much certainty concerning them.

The detailed description of these localities is reserved for the final report on the iron ores of the state, to be published during the current year.

The product of the iron mines of the State for the year ending December 31st, 1871, may be approximately set down at 450,000 tons. The data for this estimate are as follows: the ore tonnage of the Delaware, Lackawanna and Western Railroad, Central Railroad of New-Jersey, Morris Canal; the statements of the managers at Ringwood, Oxford Furnace, Franklin Furnace, and the estimate for amounts mined at new openings, and mines whence the ore has not been shipped. The aggregate of the amounts carried from stations in New Jersey on the above mentioned lines is 411,661 tons. This latter sum includes some hematite, but the amount is scarcely large enough to warrant a deduction from the above estimated product. In the annual report for 1867, the product of the iron mines was estimated at 275,000 tons. In 1864, the estimate was 226,000 tons, so that there has been an increase of 100 per cent in the product of our iron mines since that date. Dr. Kitchell said, in 1855, that the mines might yield 100,000 tons for that year, or not one quarter of their present working.

Of this total, (450,000 tons,) more than four-fifths, or about 370,000 tons, come from Morris County, leaving but 80,000 tons for Sussex, Warren, Passaic and Hunterdon counties.

HEMATITE.

The mining of this ore of iron in New Jersey is limited to a few localities, of which the Pochuck and Edsall mines north-east of Hamburg, the Beattyestown mine, and that near Carpentersville, on the Delaware, are the most important. These have not been steadily worked since they were opened, so that the total product of hematite in the state is very small in comparison with that of the magnetic ore. It is occasionally found in small masses on or near the surface, but so far no very large deposits have been discovered outside of the above-mentioned mines. Small quantities have been obtained in pits dug in our limestone valleys. A recent discovery of interest was brought to the notice of the Survey by E. P. Potter, of Pottersville, Somerset County. The specimens sent by him came from German Valley, near the Hunterdon County line. The percentage of metallic iron in these was determined to be as follows :

No. 1.	No. 2.	No. 3.	No. 4.
54.88.	56.89.	40.45.	56.12.

The geological character of this valley is very similar to that of the Musconetcong Valley, and to that of the brown hematite localities of Eastern Pennsylvania. The probabilities in favor of the occurrence of workable deposits of such ore in this valley are strong enough to justify a careful and thorough examination of its whole surface, and its superficial beds. As ore is most generally found near the borders of the limestone outcrop, either between the gneiss (or grey rock) of the bounding ridges and the limestone, or between the latter rock and the overlying slate, searches should be confined more particularly to such lines of outcrop. Explorations should, however, extend over the whole breadth of these valleys, as it is sometimes found resting upon the limestone strata, covered by quite thick beds of ferruginous loam, clay or other earthy matter.

The total product of these mines for 1871, has been estimated by good authorities at 15,000 tons. But this is below their capacity, even as at present opened and worked.

Another interesting specimen sent to the Survey laboratory came from the bottom of the Beattystown mine. It was at first supposed to be an altered limestone belonging to the underlying rock strata, but a more careful examination showed it to be a carbonate of iron, mixed with some silicious matter. On analysis, it was found to contain 82.23 per cent. of carbonate of iron. The extent of this *ore* has not been ascertained, as it was first uncovered the day of the visit to this mine.

The increasing demand for hematites and the erection of new furnaces near some of these mines, will greatly enlarge their operations, and stimulate to discoveries in other localities.

ZINC ORE.

The zinc mines of the state have yielded about 22,000 tons of ore during the past year.

ARSENICAL ORE.

During the past season specimens of so-called silver ore have been extensively circulated at Hackettstown, and in the neighboring villages of Warren and Sussex counties, the localities whence they came being kept secret. A single lump of what was said to be the same as the " silver ore," was obtained from the ridges on the east side of the Jenny Jump Mountain, and was analyzed and found to be an ore of arsenic. The specimen yielded 15.60 per cent. of sulphur, and 29.80 per cent. of arsenic. Mineralogically, it is arsenopyrite or mispickel, with probably some lölingite, but the specimen was too small to determine the latter with certainty. In the report on the Mineralogy of New York, Dr. L. C. Beck mentions this arsenical ore as occurring in crystalline limestone near Edenville, Orange County. The geological character of the latter locality is very similar to that of these subordinate ridges of the Jenny Jump Mountain range. The analysis of the New-Jersey specimen indicated traces of cobalt and nickel, but no silver could be detected. It is probable that the traditions of silver ore on this mountain are based upon this arsenical pyrites. This ore associated with other combinations of arsenic, nickel, cobalt, iron and sulphur is worked in Saxony, and extensively at Reichenstein, in Silesia, as a source of metallic arsenic, arsenious acid, or white arsenic, the pigments realgar and orpiment, and for other arsenical compounds used in the arts. The extent of the occurrence, and the character of this ore, are matters to be more fully studied, before deciding upon its probable value.

CANFIELD'S PHOSPHATE OF LIME AND IRON-ORE BED.

This new and extraordinary bed of apatite and magnetite was discovered the past season. It is at Ferro-Mont, on the Dickerson Mining Company's property, a few rods northeast of the store and by the side of the public road. The line of attraction passing through it can be traced for 1000 feet, running east of the company's farm house. The bed has been uncovered at two points, by E. Canfield, and the deepest shaft is about forty feet down—measured on the slope, of which thirty-five feet was in this mixed ore. Near this, there is a fault of thirty-five feet, towards the foot wall, *throwing* the bed to the west side of the road. The bed is eight feet wide, and has regular walls of gneiss rock, in which there is little, if any, apatite. The dip is about 65° towards the southeast. The mass of the bed is a hard and firm mixture of magnetic iron ore, and greyish white apatite. Some portions of the bed show a parallelism in the arrangement of its minerals, consisting of alternate layers, or lamellar masses, of magnetite and apatite. The proportion of this latter mineral by weight may average in the whole bed, thirty-five per cent. The two are nearly of equal bulk, the phosphate being to the iron ore, in weight, as three to five, their respective specific gravities. A portion of the phosphorus is probably in combination with the iron, as the lime is not sufficient in amount to saturate the phosphoric acid, and also as the acid solution of the separated magnetite holds some phosphoric acid but no lime. A little quartz, orthoclase, and occasionally small spangles of brown mica are seen in the ore mass. The following results were obtained in the chemical examinations of an average sample, and of a specimen rich in apatite.

	AVERAGE ORE.
Matters insoluble in hydrochloric acid	11.30
Proto-sesquioxide of iron or magnetite	54.01
Lime	17.21
Magnesia	1.65
Sulphuric acid	0.07
Phosphoric acid	14.91
Total (of matters estimated)	99.15

The specimen rich in apatite gave 53.85 per cent. of phosphate of lime. The average sample contained 31.90 per cent.

Some experiments on the solubility of this ore and its phosphate were made, the results of which were as follows:

Experiment No. 1—Five grammes of the ore, heated one-half hour in twenty c. c. of dilute sulphuric acid, containing 1.27 grammes of anhydrous acid, yielded 0.27 grammes of phosphoric acid in solution. About 38 per cent. of the phosphate of lime was dissolved in this experiment.

Experiment No. 2—Two grammes of ore digested in ten cubic centimeters of dilute sulphuric acid (of same strength as in Ex. No. 1) gave 0.127 grammes of phosphoric acid in solution.

Experiment No. 3—Two grammes of the ore, treated with the same quantity of acid as in No. 2, in a vacuum, yielded 0.161 grammes of phosphoric acid in the solution.

Experiment No. 4—In this, a specimen containing about 50 per cent. of apatite was used. The iron ore was removed by means of a magnet. Of this residue, one gramme was digested in 0 73 grammes of commercial sulphuric acid, containing 0.55 grammes of anhydrous acid, over a water bath. The resulting solution contained 0.216 grammes of phosphoric acid. equivalent to 0.47 grammes of phosphate of lime.

Experiment No. 5—One gramme of the same residue as was used in No. 4, was heated in 25 cubic centimeters of dilute sulphuric acid, containing 0.55 grammes of anhydrous acid, over a water bath, and the mass evaporated to dryness; 0.237 grammes of phosphoric acid, equivalent to 0.517 grammes of phosphate of lime, were found in the solution.

Experiment No. 6—One gramme of the same residue as in Nos. 4 and 5, was treated with 0.73 grammes of commercial sulphuric acid without heat. At the end of thirty-six hours the solution yielded 0.185 grammes of phosphoric acid, or 0.405 grammes of phosphate of lime.

The residue, after the removal of the iron ore by a magnet, and which was used in Exs. Nos. 3, 4, 5 and 6, contains an average percentage of 34.5 of phosphoric acid.

From these experiments, it will be seen that the best results were obtained by the removal of the magnetic iron ore, and the digestion of the remaining mass in acid, until it was evaporated quite to dryness. The experiment without heat did well. The previous removal of the magnetite is necessary, as can be seen by comparing experiments Nos. 2 and 3 with 5 and 6. Its removal on a large scale would give a rich ore tolerably free from phosphorus, and at the same time avoid an unnecessary waste of the sulphuric acid in the subsequent digestion. The solution from this digestion would, on evaporation, yield a superphosphate containing more soluble phosphoric acid than the average of those in the market. The separation of the magnetite and apatite could be effected by water, in consequence of the greater specific gravity of the former, or by the use of magnetic machines. The purification of the iron sands of New Zealand, of those of Moïsie, in Canada, and of other localities depends upon this difference of specific gravities, and is successfully done by washing. Magnetic machines have also been used in Canada, Northern New York, and at some European mines. For either mode of separation, a previous crushing of the ore would be necessary. The economical working on a large scale must be determined by the cost of buildings, apparatus, fuel, labor, &c. In the laboratory the profit is evident when it is understood that sulphuric acid costs from two to three cents per pound, while the soluble phosphoric acid is worth at least fourteen cents a pound. Taking the figures of experiment, No. 5, we get 73 lbs. of acid, at 2½ cents=$1.79. Soluble phosphoric acid, 23.7 lbs., at 14 cents per lb.=$3,32. And 3.32—1.79=$1.53 per cwt. of separated apatite, equal to $30.60 per ton. Whether or not this margin be broad enough to cover the expenses of the necessary manipulation is for practice to decide.

Phosphate of lime is so valued in England, that in Cambridgeshire beds of coprolites from nine to sixteen inches thick, are uncovered and profitably worked, when the overlying earth, clay &c., is fourteen feet thick. And this, too, where the first cost of the land is large. The *vein* mass or material from these beds is washed, and then made into superphosphate, in the same manner as bones and some native guanos The washed coprolites contain on an average 56 to 60 per cent. of phosphate of lime, and sell at fifty shillings, or about $13.50 per ton. In Nassau, Germany, the mining of native phosphate of lime as a source of superphosphate has attained large dimensions. In 1867, the product of the Lahn and Dill districts, in that province, amounted to 62,500 tons. The average price of this native phosphate was about $9 per ton—*i. e.*, for such as contained from 60 to 70 per cent. of phosphate of lime. In our own country the phosphatic deposits of South Carolina yield a large amount of raw material for the manufacture of superphosphates.

As an additional source for such material, this new and extraordinary mine appears to be worthy the attention of those interested in and conversant with the business of manufacturing superphosphates.

MICA MINES.

The first to be described is located about three miles north of Stewartsville, and on the west bank of Merrill Creek, Harmony Township, Warren County. The valley is narrow, and in places ledges of rock crop out so that much of the surface is too stony for cultivation. At several points the soil contains a considerable proportion of mica, indicating the existence of this mineral in the underlying rocks of the valley. In the disintegration of the rock, this has been left unchanged, as one of the constituents of the resulting rock covering.

The openings in the exploration of the company are a few feet above the stream, and just below a shoulder or rib of the sidehill. The most northerly of these is a drift running twenty feet into this shoulder. At the further end it is about fifteen feet deep, and its average width is 2½ feet. The heading of this drift is in gneiss, as are the side walls. The whole mass of the vein is mica, the cleavage planes lying in all directions. South of this drift there is a broader excavation in the hillside, it being about twenty-five feet long, and eighteen feet deep. Here the mica appears to be in veins one to two feet thick. traversing the gneiss of the hill. This latter rock is micaceous. with some beds of a granitoid character. Associated with the mica, occur quartz, feldspar and asbestus. Some portions appear to be mixtures of whitish pyroxene and mica. Between these two openings, and south of the last described, there are several excavations of lesser depth, but all showing the same general character—veins of mica traversing the gneissic beds of the country. The mica may be considered as constituting the mass of granitic dikes, which lie in, and cut the bedded rocks of the district, differing from ordinary granitic and syenitic dikes of our azoic formation in the larger proportion of mica; amounting, as it occasionally does to an entire exclusion of the minerals usually accompanying it, and forming the mineral aggregate of such masses. The mica of this locality is a brown potash variety. known as muscovite. In thin plates it is transparent and almost colorless. The present company made these openings the past summer, under the superintendence of their agent, R. J. Rymer, of Stewartsville. The explorations already made show that the masses of mica are quite irregular in their extent, and from the known character of such dikes nothing can be predicated of them with certainty, beyond what is in sight.

Another, so-called, *mica mine* has been opened during the year past by Clarkson Bird, of Broadway, on Scott's Mountain, about one mile north of that village. The property was leased from J. Fritts. The *mine* is on the southeast slope of the ridge, near the road to Springville. It consists of two small excavations, about twenty feet apart, one being about fifteen feet (vertically) higher up on the hillside. The covering was about four feet thick of rotten gneiss and earth. The mica is free from impurities or admixture of other minerals, but the cleavage planes are much bent and not very large—not generally exceeding a few inches square. The upper portions of the micaceous mass are quite loose, so that the plates are easily split out. Deeper, the mass is more solid, and the plates appear larger. The surface of the vein or dike dips or descends westerly into the face of the hill. The rock on top of the vein is a crumbling gneiss, consisting of orthoclase, brown muscovite, and a small per centage of vitreous quartz. Some of the mica from the bottom will measure 8x10 inches. Thus far the work has been for exploration alone.

The mineral here is the same as at the mine of the last described locality, muscovite, excepting that it is darker colored, being a deep brown, to amber color. The surface indications of the same ridge, further to the south, are favorable to the existence of the same mica dikes beneath.

ROAD MATERIALS AND ROADS.

Good roads are essential to any community that would thrive. The losses in time, wear of teams and carriages, and diminished amount of work done, are enough to take off a large share of the profits of ordinary business. Up to a very recent date bad roads have been the rule, and good ones the exception in New-Jersey. Heavy sand in the southern part, and mud and stones in the northern and middle portions of the state have too often been the road materials.

In our southern counties there is an abundance of gravel and gravelly loam, and nearly all of the ground is naturally well drained. In such case, it is easy to make good roads. It is only necessary to shape its surface to the proper form, to make ditches and drains to carry off all the water, so that none shall stand upon the road or on the sides near its level, and then to cover its surface from six inches to a foot in thickness with gravel, containing loam enough to make it pack, and the road is done. Most excellent roads are made in this way. And there are hundreds of miles of them in the different counties of Southern New Jersey, over which it is a delight to drive. There is no reason why all the roads should not be of this character. Their cost varies from $1,000 to $1,500 per mile, according to the greater or less distance that the gravel has to be carted. In a few instances, this turnpiking has been done by the townships, but much more has been the work of private corporations acting under charters from the state.

In the northern half of the state there is much more difficulty in making good common roads, gravel is not so abundant and the soil is not so well underdrained. Roads that remain in good order throughout the year are not common. Those about Madison, Morris County, possess this excellence, and they make it one of the most attractive and desirable places of residence in the whole state. Roads generally, wherever the soil is not dry enough, must first be drained by tile or stone underdrains, and then made of the proper form and graveled. In Orange, Essex County, trap rock has come into use for making roads, with the most satisfactory results. The material is hard and tough, and the roads made of it are solid, smooth and durable, and for their excellence of moderate expense. They are so well liked that their use is extending rapidly. Several miles are already built. This has been done by property owners, by townships, and by street commissioners. High street, in Newark, and South Orange Avenue, are both in process of paving with it. It is known as the Telford pavement, and I copy a description of it from the specifications for that in High street, which were sent me by Francis H. Dawes, Esq., of Newark:

"The roadway to be excavated, graded and properly leveled to a depth of sixteen inches below the top of the gutter-stone; the form of the cross-section to be in every respect the same as that to be given to the surface of the pavement. The road bed is then to be rolled with the steam roller until approved by the Street Commissioner. On the road bed thus formed, a bottom course or layer of stones of an average depth of eight inches is to be set by hand in the form of a close firm pavement, the stones to be placed on their broadest edges, lengthwise across the street, and so as to break joints as much as possible; the breadth of the upper edges not to exceed eight inches. The interstices are then to be filled with stone chips, firmly wedged by hand with hammers, and projecting points broken off. The whole surface of this pavement to be subjected to a thorough setting or ramming with heavy sledge hammers. The intermediate layer of broken stone is then put on to the depth of six inches, the stones to be broken to a size not exceeding three inches diameter, and thoroughly rolled down with the steam roller, after which the surface layer of broken stone, of a size not exceeding two inches in diameter, is to be put on and evenly spread to such depth as may be required to bring the surface when thoroughly compacted with the steam roller, to the proper grade and cross section; making the total depth of broken stone eight inches, and the entire thickness of the pavement, when completed, sixteen inches. Any irregularities appearing during the rolling are to be carefully filled with additional material, so as to produce an even surface. When the surface is thoroughly rolled, a binding, composed of the screening and detritus of the broken stones with sand, is to be spread thereon, sprinkled, and thoroughly and repeatedly rolled with the steam roller until the surface becomes firm, compact and smooth. Any binding material remaining on the surface is then to be swept off and removed. For the foundation, any stone not liable to be affected by the action of the frost may be used after having been approved by the Street Commissioner. The broken stone in the intermediate and surface layers to be exclusively of trap rocks !"

When the traffic is lighter over the road the broken stone may be thinner—down to twelve or even ten inches, and the breadth may be less—sixteen or twenty-four feet. The cost of these roads varies with the distance to which the broken stone has to be hauled. That in Main street, Orange, which is sixteen inches deep, cost $1.90 a square yard. Centre street, which is paved thirty feet wide and a foot deep, cost $2.50 a running foot. The road going up the mountain is twenty feet width of pavement, and from eight to twelve inches depth of stone, and was built for one dollar a square yard. The road from the stone-breakers, on the Northfield road, for a mile down, waa graded and paved for a dollar per running foot. The contract for paving High street, Newark, was let for $1.90 per square yard, which was probably too low. Other contracts for like work have been taken at $2.25 to $2.50 a square yard. The stone is broken in a Blake's rock crusher, and when driven by a ten or twelve horse engine, ninety tons or sixty cubic yards can be broken in a day. Daniel Brennan, jr., of Orange, has done a large part of the work there, and his arrangements for doing it are very complete. He quarries the stone near the top of the First Mountain, and the breakers are so located that the carts dump the stone close to them, and the broken stone are elevated, sorted and deposited in proper shoots by machinery, and wagons are driven directly under the shoots and the stone falls into them, thus needing no handling. The excellence and economy of these roads is such that I am sure it will be a great public benefit to have them more thoroughly known. I do not think that better stone roads can be found anywhere in the world than these in Orange; and it will be worth while for any who are considering the subject to go and see them.

Trap rock is abundant in all the middle portion of the state. Bergen Hill, and its extension to the Palisades, is of this rock, so are the First, Second and Third Mountains west of Newark extending from Pluckemin and Somerville to Paterson and almost to the state line. Rocky Hill, Mt Rose, Sourland Mountain, Goat Hill, Pickle's Mountain, and many smaller outcrops in the red sandstone region are of this same rock. The gneiss and gray rocks of the Highlands furnish a good material for stone roads, but not equal to the trap. The stone is not so tough, and it wears into dust much faster. Limestone is a still softer rock, and, of course, is not so well adapted for this purpose.

Those who are curious in regard to the literature of this important subject, will find in the Reports of the United States, Commissioners, on the Paris Exposition, a capital one by Arthur Beckwith, C. E., "On Macadamized Streets and Roads." The Legislature of Massachusetts, for 1869, offered prizes for the best essays on roads and road-making, and a valuable document is published containing interesting and instructive essays, to which the prizes were awarded. The annual reports upon the New York Central Park also contain accounts of its excellent roads.

LIMESTONES AND LIME.

The limestones of the northern part of the state continue to furnish a large amount of lime for agricultural purposes. The yearly product of our kilns has not, however, greatly changed within the past three or four years, and the business has not moved from the localities mentioned in the "Geology of New Jersey," in 1868. In that report the superiority of the non-magnesian limes to the ordinary dolomitic or magnesian limes and the localities where such pure or non-magnesian limestones occur, were indicated, (see pages 388, 396—399, 400—404, and 410—413 of "The Geology of New Jersey, Newark, 1868."

During the past season, some crystalline limestones from the valley of the Wallkill, Sussex County have been analyzed, and three of the analyses are here presented :

	No. 1.	No. 2.	No. 3.
Lime	51.06	53.53	51.96
Magnesia	3.02	1.73	2.92
Oxide of Iron and Alumina	0.80	0.50	0.20
Carbonic Acid	43.44	43.97	44.03
Graphite and matters insoluble in acids	1.40	0.55	0.20
	99.72	100.28	99.31

No. 1 is a surface specimen, from near a new kiln on lands of J. B. Titman, northwest of Sparta. No. 2 is the ordinary white or crystalline limestone, which is burned at Franklin Furnace. No. 3 is from West Vernon, and was sent to the Survey laboratory by J. H. Brown, of Franklin. None of these specimens are dolomitic or true magnesian. The practical value of these as a source of lime is yet a matter of experiment, and the results to be obtained are looked forward to with interest and hope. And the opening of the Midland Railway which passes directly across these beds of limestone will make them available for a large district of country.

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The officers of the Survey will take pleasure in analyzing specimens of ores, minerals, fertilizers, &c., which are found within the state, and promise to be of public interest. They may be sent to Prof. George H. Cook, State Geologist, New Brunswick, N. J.

APPENDIX.

Publications of the New Jersey Geological Survey.

Geology of New Jersey, 899 pages large octavo, illustrated by 108 photolithographic engravings and woodcuts, and six mine maps; and accompanied by a portfolio containing the following maps, in sheets:

1. Azoic and Paleozoic Formations, including the iron-ore and limestone districts; colored; scale 2 miles to an inch:

2. Triassic Formation, including the Red Sandstone and Trap-rocks of Central New Jersey; colored; scale, 2 miles to an inch:

3. Cretaceous Formation, including the Greensand Marl Beds; colored; scale, 2 miles to an inch:

4. Tertiary and Recent Formations of Southern New Jersey; colored; scale, 2 miles to an inch:

5. Map of a Group of Iron Mines in Morris County; printed in two colors; scale, 3 inches to 1 mile:

6. Map of the Ringwood Iron Mines; printed in two colors; scale, 8 inches to 1 mile:

7. Map of the Oxford Furnace Iron-ore Veins; colored; scale, 8 inches to 1 mile:

8. Map of the Zinc Mines, Sussex county; colored; scale, 8 inches to 1 mile:

Price of the book and portfolio of maps, $6.50.

Geology of New Jersey, as above, without portfolio of maps, but containing a folded and colored map of the State, on a scale of 5 miles to 1 inch. Price, $4.00.

Geological Map of New Jersey, on a scale of 2 miles to 1 inch; colored and mounted on rollers. It gives the Geology of the State the same as Maps 1, 2, 3. 4. in the portfolio, and is essentially these combined in one map. Size 5½ by 7½ feet. Price $8.00 per copy.

The prices are fixed to merely cover the cost of paper, printing and binding ; the expenses of the Survey and preparing book and engravings being paid by the State.

These publications can be had from Prof. George H. Cook, State Geologist, New-Brunswick, on remitting the price, or through the booksellers.

The books are also kept for sale at these prices by William T. Nicholson, of Trenton ; Morgan & Shivler, of New-Brunswick ; M. R. Dennis & Co., Newark, and D. Van Nostrand, of New York City.

The work is in the following public libraries, where it can be consulted :

In all the State Libraries ; in some other of the large public libraries in different parts of the United States, and in all the public libraries in New Jersey, and in the adjacent cities of New York and Philadelphia. It is also in the offices of most of the County Clerks.

The Annual Reports for 1869, 1870 and 1871, can be had on application to the State Geologist.

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ANNUAL REPORT

7960

OF THE

STATE GEOLOGIST

OF NEW JERSEY,

FOR THE YEAR 1872.

TRENTON, N. J.:
THE STATE GAZETTE—MURPHY & BECHTEL, BOOK & JOB PRINTERS.
1872.

J. D. Whitney.

HARVARD UNIVERSITY.

WHITNEY LIBRARY,

MUSEUM OF COMPARATIVE ZOÖLOGY.

GEOLOGICAL SURVEY OF NEW JERSEY.

ANNUAL REPORT

OF THE

STATE GEOLOGIST,

FOR THE YEAR 1875.

TRENTON, N. J.:
Public Opinion—Wm. S. Sharp, Steam Book and Job Printer.
1875.

c

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STATE GEOLOGIST.

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To His Excellency, Joseph D. Bedle, Governor of the State of New Jersey, and President of the Board of Managers of the State Geological Survey:

SIR—I have the honor herewith to submit my annual report on the progress and present condition of the Geological Survey of the State.

With high respect, your obedient servant,

GEO. H. COOK,
State Geologist.

New Brunswick, November 26, 1875.

REPORT.

The work of the Geological Survey of New Jersey, has been prosecuted during the past year in all its departments. Having been organized for the purpose of developing the natural resources of the State, its investigations have necessarily taken a much wider range than would be involved in describing the composition and structure of the materials of our rocks and soils, and of the successive changes in animal and vegetable life, changes in climate and in elevation above, or depression below the level of the sea. The language of the act authorizing the survey, plainly indicates that the work done was not in the interest of geological science alone, but also in the applications of geology to the benefit of agriculture, mining and metallurgy; to making public our supply of materials for which industry may find profitable use, or by which the wealth and comfort of our people may be increased. The instructions received from the Board of Managers of the Survey have been in accordance with their interpretation of the law. And the results of the work done, have shown the wisdom of their interpretation. Prof. Rodgers' Final Reports on the Geology of New Jersey was published in 1840. His work was well done, and it was ably presented in that report, and the publication was of great benefit to the State. The annual reports of Dr. Kitchell and his assistants in 1854, 1855, and 1856, began the development of our geology in its practical and economical relations. Though this work was stopped for financial causes, it brought out in strong light the great value of our agricultural, mineral and manufacturing resources. And the yearly reports made to this Board, since 1864, and published, have helped to make Jerseymen, as well as those of other States, appreciate the value and capabilities of our natural advantages.

To understand the growth of our State, notice the population at each United States census, and the per centage of growth for each ten years.

Date.	Population.	Per Centage of Increase.
1790	184,193	
1800	211,949	15.10
1810	245,555	15.86
1820	277,426	13.04
1830	320,823	15.58
1840	373,306	16.36
1850	489,555	31.14
1860	672,035	37.27
1870	906,096	34.83

The increase in per centage for the last twenty years is greater than the average for the whole United States; and in the ten years, from 1860 to 1870, New Jersey rose from being the twenty-first in population to the seventeenth.

The increase in wealth has been still more rapid. The value of all her real estate and personal property was in

1850	$200,000,000
1860	467,000,000
1870	940,976,064

and she rose in the rank of States, in wealth, between 1860 and 1870, from the sixteenth to the eighth place.

The value of farm lands per acre is higher than in any other State in the Union, and it has increased more than any other for each of the last three decades. The use of our marls, lime, fish-guano, and other natural fertilizers has greatly extended, and the annual value of our agricultural products has doubled. The yearly product of our iron mines has more than trebled in the last ten years. The manufacture of our white clays into fire-bricks and pottery, which now produces some millions annually, has mainly grown up within the same period.

This growth in population and wealth which is unexampled in any other of the older States, is due largely to to the circumstances of the times, and our peculiarly advantageous location; but it is due to the Board of Managers of this survey, to say that their publication of the resources and advantages of our State have had a very important influence in calling in both capital and industry from other States.

Assistants.

I have been assisted in the work of the Survey during the year by:

Prof. John C. Smock, Assistant Geologist, who in the early part of the year, was occupied in the survey of the clay district of Middlesex county, and since midsummer has been collecting representative specimens of our rocks, ores, and other natural products for the Centennial Exhibition at Philadelphia.

Edwin H. Bogardus, Chemist to the Survey, has been steadily in the laboratory analysing ores, clays, waters, &c., and testing specimens sent from various parts of the State for examination.

Jas. K. Barton, Surveyor and Engineer, has completed the surveys and levels for the maps of the clay district of Middlesex county, and has drawn the map with its contour lines for the engraver.

Robert A. Meeker, B. S., and Edward A. Reiley, students of Rutgers College, have been with Prof. Smock in making collections for the Centennial Exhibition.

Expenses.

The expenses of the year have been increased by the cost of surveying, and leveling, and drawing maps; but as the charges in collecting specimens have been paid by the State Centennial Commission, the regular appropriation of five thousand dollars for the support of the Survey, will meet its liabilities. It is, however, only by the most rigid economy that the expenses have been kept within this amount, and the work continued. The Board of Managers in their determined purpose to economize the money of the State, have never taken anything from the appropriations for personal expenses, but have paid their own bills.

The Year's Work.

This may be conveniently presented under the following heads:

1. Survey and Final Report on the Fire and Potters' clays of Middlesex county.
2. Collection of specimens of rocks, ores, minerals, soils, &c., for the Centennial Exposition, and the State Cabinet.
3. On the construction of a Topographical Map of the State, and the aid furnished by the U. S. Coast Survey, in preparing for it.
4. Drainage.
5. Water supply for towns and cities.
6. Laboratory work, regular and miscellaneous.

1.

Survey and Final Report on the Fire and Potters' Clays of Middlesex County.

In the last annual report it was mentioned that a special report and geological map of the clay district of Middlesex county was in course of preparation. It is now nearly done; the map is in the engraver's hands and will be completed in a few days, and the material for the report is ready to be written out. Work in the field has delayed the writing, but it is expected to have the report ready for distribution this winter.

The clay for fire-bricks, pottery, &c., annually dug in this district is worth $1,000,000, and a large part of it is worked up, within the State, into products worth as much more. The business of making fire-brick and other refractory articles, and the manufacture of fine pottery are having a very rapid development in our country, and we have an abundance of the materials used in their production. This report describes in detail, and the map shows the structure and arrangement of the various beds of clay, kaolin, &c. The beds lie in an order and position that is regular and easily understood, now—the obscurity that has enveloped them being entirely due to the changes which time and superficial wear have made in the condition of the gravel and earth upon the surface.

Heretofore no order of succession, nor any connection have been traced out between the different clay pits; there is no plainly marked difference between the clays from different parts of the district; fossils are not found in those beds which are worked; and the surface of the country, though uneven, presents no marked differences of material in its composition. The great number of openings that have been made for clay, have, however, furnished the means for making careful and extended comparisons. And they have proved that all the clay, kaolin, &c., in this district are in uniform layers, which are of several miles in extent. These layers are not level, but *dip* or slant down towards the southeast with a regular descent of about 40 feet per mile.

Towards the northwest, layers or *beds* must come to the surface or *crop out*, and the higher the ground the farther towards the northwest the *outcrop* of a bed will be. If the beds are uniform in the amount and direction of their dip, it follows that when the exact height of a bed at a given place is known, its height at any other place can be determined. The country has been surveyed and its height above tide has been ascertained by leveling, and the map is drawn so as not only to give outlines, but heights also. Lines of level or *contour lines* are drawn on the map so as to indicate the height of the surface above mean tide, at intervals of ten feet perpendicular. The lines are really drawn where the water's edge would be if the land should sink ten feet, twenty feet, thirty feet, or any other even ten feet, up to the highest ground in the district which is 240 feet. A section and profiles are also drawn on the map to show the thickness of the several strata, and their height above tide at various places. Understanding these, an inspection of the map will enable any careful and intelligent person to determine whether any one of the clay beds is beneath the surface, at any given place, and if there, how deeply it is covered with earth. The only uncertainty is in regard to the thickness of the drift sand, clay, gravel and boulders, which cover the surface, and which have been deposited there long since the formation of the clay beds, and which are not in any regular layers or order. The collections of characteristic specimens, the analyses of clay used for different purposes, and the lists of clay pits worked are all ready, and will be put in order for exhibition in the State Cabinet, at Trenton, before the close of the winter.

The map is drawn on a scale of three inches to one mile, and engraved in the best manner. And it is hoped that with the descriptive matter of the report, it will supply the want which has been long felt by those engaged in this important branch of industry.

2.

Collection of Specimens of Rocks, Ores, Minerals, Soils, &c., for the Centennial Exposition, and the State Cabinet.

Collections of representative specimens of rocks, ores, minerals, soils, fertilizers, building stones, clays, sands, and other natural and useful products, have been needed for our State collection and for institutions of learning. The demand for such specimens, in order to exhibit properly the richness and variety of the natural products of New Jersey at the approaching Centennial Exposition in Philadelphia, has necessitated making the collection this year. Prof. J. C. Smock, with two assistants, has been steadily at this work since July 7. The collection of rock specimens, iron and zinc ores and minerals, in all the northern part of the State, and in the clay district, is finished. Specimens have been collected from at least three hundred and seventy localities, one hundred of which were iron mines, and the specimens number more than two thousand. There are still about one hundred localities to visit, and perhaps three hundred specimens to collect, and when this is done the series will be completed as fully as desirable at present.

The specimens for the Centennial will be arranged in the State Cabinet at Trenton this winter, and removed to the Exposition in the spring. At the close of the Centennial they will be brought back to the State Cabinet and arranged there for permanent exhibition. Duplicate specimens have been collected for the geological museums of Princeton and Rutgers colleges. The catalogue of specimens is herewith presented, and it is hoped that the Board will authorize the printing of such portions of it as may be needed for the instruction of those viewing the collection.

3.

ON THE CONSTRUCTION OF A TOPOGRAPHICAL MAP OF THE STATE, AND THE AID FURNISHED BY THE U. S. COAST SURVEY IN PREPARING FOR IT.

It is everywhere recognized at the present time that the best interests of any country require an accurate map of all its territory. It should have a map which will show, not only the outlines of its civil divisions, and the location of its rivers and mountains, but which shall also show the height of every part of its surface above the level of the sea. Such a map is indispensable for the accurate description and exhibition of its geology. It is of the highest importance for showing areas of drainage and sources of water supply. It furnishes at once the information needed for the judicious location of roads and railroads; and it offers to every citizen, old and young, that practical information regarding geography of which they have heretofore felt the want.

As countries become thickly settled, and land increases in value, the making of such maps becomes necessary. The older countries of Europe have been engaged, for many years past, in surveying for such maps of their territory. Great Britain, France, Belgium, Germany, Switzerland, Norway, Sweden and Russia, all have such maps. The survey of England was begun in 1784, and was completed a few years ago,—and now the survey for mapping the whole kingdom, on a scale of six inches to the mile, instead of the former of one inch to the mile, is in progress.

In our country little has yet been done. The U. S. Coast Survey, organized in the interests of commerce and navigation, has done excellent work in the survey of our harbors, coast lines and approaches by water. Its maps will compare favorably with those of any other nation. A trigonometrical survey of Massachusetts was made between 1830 and 1840, but it was not followed up by accurate topographical surveys, and the undertaking was not carried through satisfactorily. A movement was begun in the Massachusetts Legislature last winter, for the organization of a new scientific survey of the State. In New Jersey a trigonometrical and topographical survey was begun in connection with the Geological Survey in 1854, and was continued through 1855 and 1856. It was not continued further for lack of money. Some of the work then done has been used in the construction of various State and county maps, since that time, while a large part, from being unfinished, was lost.

The U. S. Coast Survey has already surveyed our whole Atlantic coast, has determined the precise latitude and longitude of many points along the shore, and that of prominent ones miles inland. It has a supply of the most accurate instruments for such surveys, and a large corps of trained and skilful assistants are constantly employed in its work. To the Coast Survey the States naturally look to determine for them the precise geographical positions of a sufficient number of points to form a basis upon which to construct their maps In 1871 the Coast Survey received an appropriation, with the proviso "that the triangulation shall determine points in each State in the Union which shall make requisite provision for its own geological surveys." This appropriation has been continued every year since. The Coast Survey assistants determined for us, in 1873, the true position of the western terminus of the boundary line between New York and New Jersey, and also the true direction and length of that line. In the spring of 1875 they appointed an assistant to carry on the work of selecting points for extending their triangulation over our whole State. Prof. Edward A. Bowser, of Rutgers College, received this appointment, and has been engaged all summer in his work. The accompanying map of New Jersey has been prepared to show the extent of the Coast Survey work already done in the triangulation of the State, and the additional stations which have been selected this year by Prof. Bowser. It will be seen at once that a large amount of work has already been done at the expense of the general government, for New Jersey.

The importance of this triangulation for the accurate location of points, is apparent when we consider that however careful and accurate a surveyor's map may be made, it cannot be accurately placed upon any general map, unless the location in latitude and longitude of some accessible point is known and can be referred to. These points should be so numerous that they can be easily referred to by persons in every part of the state. It will be seen that the triangles upon the map are of different dimensions. The largest ones belong to the *primary triangulation*, which extends from the measured base near Fire Island, on the south shore of Long Island, along the whole coast from Massachusetts to Maryland. The sides of many of these triangles are thirty miles or more in length, and all the work connected with the measurement of their angles and the computation of their sides, has been done with the best instruments and by the most accurate methods. From the sides of the primary triangles, numerous other and smaller triangles have been measured and the places of their angles determined. These are the *secondary triangles*. On the sides of the secondary triangles, observations for a set of smaller triangles are made. These are much more numerous and are intended to reach all the points whose position it is important to determine. These are *tertiary triangles*.

The expense of determining all these points has been borne by the United States. It is much heavier than could have been borne by our State, though the work is of great value to us; and it is to be hoped that the triangulation will be continued by them until the whole State is included in the net-work of triangles.

It devolves then upon the State to continue its geological and topographical surveys, so as to use these triangulation points for the accurate basis of our maps. We already have topographical surveys of one hundred and fifty square miles of country in the richest part of our iron ore region, but we lack the location of points in them, and these the coast survey will now give us. The whole iron ore region of nine hundred square miles needs to be surveyed and represented on a topographical map of large scale. Its benefits to our mining interests would repay its cost in a single year.

The map of the clay district of Middlesex county, which accompanies the special report on our fire-clays, is intended to be a specimen of topographical maps such as we need. It is based on the coast survey triangulation which has already covered that part of the State, and the surveys and levels have been carefully made and checked so as to render them accurate and reliable. Its geological accuracy has also been verified by careful comparison and measurements; and a study of it with the accompanying profiles and section, will enable any intelligent explorer or workman to know the place and depth beneath the surface of any bed of clay in the whole district mapped. The regularity of structure exhibited on this map is characteristic of all the south part of the state, and maps of a kind like this will enable all who are interested to know what materials are underneath the surface at any place and the exact depth at which they can be met. Such maps are now needed for the marls, glass-sands and clay-beds of southern New Jersey.

Law for the protection of Monuments and other survey marks.—Inquiry has been made of the survey in regard to the proper preservation and protection of monuments. station marks, &c., and the laws upon the case. An act in relation to the subject of this inquiry was passed for the benefit of the U. S. Coast Survey in 1841. A copy is herewith presented, with the request that the Legislature be asked to extend its provisions to the monuments of the Geological Survey. (*Laws of New Jersey*, 1841, *p.* 112.)

"An Act concerning the survey of the coast of New Jersey.

"Sec. 1. *Be it enacted by the Council and General Assembly of this State, and it is hereby enacted by the authority of the same*, That it shall and may be lawful for any person or persons employed under and by virtue of the act of the Congress of the United States, entitled "An act to provide for surveying the coasts of the United States," passed the tenth day of February, in the year of our Lord eighteen hundred and seven, at any time hereafter, to enter upon any lands within this State for the purpose of exploring, surveying or leveling, or doing any other matter or thing which may be necessary to effect the objects of the said act; and to erect any works, stations, buildings and appendages necessary for that purpose, doing no unnecessary injury to private or other property.

"Sec. 2. *And be it enacted*, That in case the person or persons so employed under the said act can not agree with the owners or possessors of the said land so entered upon for the use of the same, or upon the amount of the damage done thereto, it shall and may be lawful for the person or persons so employed, or the owners or possessors of the said lands, to apply to one of the Justices of the Supreme Court of this State, who shall thereupon appoint three disinterested and judicious freeholders, resident in the county wherein the said lands do lie; which said freeholders, having first severally taken and subscribed an oath or affirmation before some person duly authorized to administer the same, faithfully to examine the matter in question, and assess the damages sustained by the owners or possessors of the lands so occupied, by reason of such occupation thereof, according to the best of their skill and understanding; and the said freeholders, or a majority of them, having given to the owners or possessors of the said lands, and to the person or persons so employed, five days' notice of the time and place of meeting, shall proceeed upon the testimony of witnesses, to be by them sworn or affirmed and examined, or upon their own view, or both, to assess the said damages; and shall make report thereof, in writing, under their hands and seals, and file the same within five days thereafter in the office of the clerk of the county in which the said lands do lie; which report, as between the said parties, shall be final and conclusive, and the amount so assessed and reported, be paid to the said owners or possessors of the said lands within ten days after the filing of the said report; and upon default of such payment, any person or persons so entering upon the said lands shall forfeit all his or their right of entry given by this act, and shall be taken and considered as guilty of trespass, in like manner as if this act had not been passed; and the said Justice of the said Supreme Court shall, on application of either party, tax and allow such costs, fees, and expenses, to any person or persons performing any of the duties prescribed in this act, as he shall think equitable and just, which shall be paid by the person or persons employed under the said act, within the time above limited.

"Sec. 3. *And be it enacted*, That if any person or persons shall wilfully injure, deface or remove any signal, station, monument, or building, or any appendage thereto erected, used or constructed under the said act of the Congress of the United States, or under this act, such person or persons so offending shall severally forfeit and pay the sum of one hundred dollars, with costs of suit, to be sued for and recovered by any person who shall first sue for the same in any court having cognizance thereof; one half thereof for the use of the said prosecutor, and the other half thereof to be paid to the overseers of the poor in the township in which the offence was committed, for the use of the poor of said township, and shall be also liable to pay the amount of damages thereby sustained, to be recovered, with costs of suit, in an action on the case, in the name and for the use of the United States of America in any court of competent jurisdiction.

"Sec. 4. *And be it enacted*, That this act shall go into effect immediately after the passage thereof.

"Passed, March 11th, 1841."

Drainage.

The commissioners for the drainage of the Great Meadows on the Pequest, in Warren county, have been pushing their improvement during the entire year. Pecuniary difficulties have made its progress slower than it should have been. But the heavy work of cutting down the outlet is now advancing finely, and it is expected that before winter sets in the bed of the stream where it leaves the meadows will be lowered five feet. The work is done by a steam dredge, and is begun at the upper end of the obstruction where the water is deep enough to float the scow and machinery. The dredge moves down the channel, cutting this out to the proper width, depositing the earth taken out upon either side and deepening it sufficiently to hold water enough to float the dredge down to its work. The plan is successful, and the entire outlet can be worked through in a few months. The slight lowering of last year, which was only about a foot, has made a decided improvement in the dryness of the surface. The logs and other temporary obstructions in the channel of the Pequest, have been taken out for four miles above the outlet, and the remainder will be cleared out early next year.

The improvement of the outlet and the clearing out of the channel through the meadows will complete the first step in an improvement which will remove an unsightly and insalubrious marsh, and add several thousand acres of rich farming and grazing land to the State.

The commissioners for the drainage of lands on the Passaic and its branches, between Little Falls and Chatham, have not yet begun active operations.

There is difficulty in raising money to pay for the water-power, or the lands taken, and to pay the cost of doing the work, while the benefits of the improvement are not seen, and the taxes to repay the expenses are not yet assessed.

The lands themselves are not a certain source of income to any one, in their present condition. The entire crop of hay on them this year was lost by freshets. That on the Passaic was worth at least $100,000, and the land owners are that much poorer than they would have been if the floods could have had free vent. Such losses have occurred several times within the last ten years. Of course, people who depend upon property of this kind for their living, cannot have money to advance. The benefits of such drainage are shared by all the uplands lying in their vicinity, and by all the people whose health can be affected by the miasm from them, and it would be but justice if such lands and such people were to share the expenses of the improvements by which they are to be benefited. If the assessments could be made by the regularly constituted township authorities, and on the ground of public benefit, the financial credit of such enterprises would then be secured, and the cost, however, divided in the final settlement, would not be burdensome, even if it were all collected from the lands drained.

The subject of drainage for health as well as for profit, is receiving the hearty support of enlightened and prosperous communities everywhere. The American Public Health Association asked from this survey a report to be read at their annual meeting in Baltimore, in November of this year, "on the drowned lands of Orange county, N. Y., and Sussex county, N. J., and the sanitary and economic importance of drainage for them." This report was prepared and read as requested. The U. S. Commissioner of Agriculture, in September, addressed to Governor Bedle, president of this board, a letter asking for information relative to wet lands. The letter and its answer are as follows:

"DEPARTMENT OF AGRICULTURE,
"WASHINGTON, September 21st, 1875.

"*To the Governor of New Jersey:*

"This Department desires to collect all available information relative to the extent of boggy, water-soaked, marshy and swampy, or occasionally overflowed lands in the several States and Territories of our country. It is presumed that such data exists as a matter of record in some department of each State, or is of general knowledge among its well-informed citizens. We wish, also, to learn to what extent and by what means this class of lands are being reclaimed for economic and agricultural purposes.

"We make similar inquiries of all the States, and, to facilitate replies, formularize the points upon which we particularly desire information.

"We would also be pleased to receive suggestions relative to the reclamation of such lands from an economic, geographical, and sanitary point of view. You will much oblige by furnishing the solicited information, and, if convenient, it will be esteemed a favor to receive your answer by or before the first of November.

"Respectfully,
"FREDERICK WATTS,
"*Commissioner of Agriculture.*"

Hon. Frederick Watts, U. S. Commissioner of Agriculture:

SIR—The Hon. Joseph D. Bedle, Governor of New Jersey, has requested me to reply to the circular of September 21st, from the Department of Agriculture, and to furnish information in relation to wet lands in this State, and I respectfully submit the following:

1. Name of State.

New Jersey.

2. What extent, in acres or square miles, of boggy, water-soaked, swamp and marsh lands are there in your State? Please give locality and local name of swamps.

There are 295,000 acres of tide-marsh in the State. It borders on Newark Bay, Staten Island Sound, Raritan River and Bay, the sea-shore—from Sandy Hook to Cape May, and the shores of Delaware Bay and River as far up as Camden. The amount in each county is as follows:

Bergen	11,910
Hudson	12,896
Essex	4,282

Union	4,445
Middlesex	7,335
Monmouth	5,958
Ocean	31,155
Burlington	25,429
Atlantic	38,003
Cape May	58,824
Cumberland	51,078
Salem	28,602
Gloucester	9,958
Camden	3,652
Mercer	1,946
Total	295,474

Of the lands wet and liable to overflow in freshets, there are 10,000 acres on the Wallkill, in Sussex county; 5,500 acres on the Pequest river, in Warren county; 25,000 acres on the Passaic, in Somerset, Morris, Essex and Passaic counties; 1,600 acres on the Paulinskill, in Sussex county, and many tracts of smaller size in other parts of the State.

3. Has there been a survey of this class of land y your State?

The area of these lands has been found while prosecuting the Geological Survey. No direct survey has been ordered by the Legislature.

4. If published, please furnish this Department with a copy, or furnish us with information as to where it may be seen.

The Geology of New Jersey, and the annual reports of the Geological Survey for 1869 1870, and 1871, give extended notices of these lands.

5. What amount of such lands have been reclaimed in your State?

Perhaps 25,000 acres of tide-marsh has been reclaimed; and the swamps and overflowed lands along the rivers have been partially reclaimed.

6. Please state what successes have attended efforts for their reclamation.

For full answer to this question see Annual Report of State Geologist for 1869, pp. 23–32. The reclamation is successful and profitable.

7. Please state what methods have been adopted for the reclamation of these lands.

For this also see answer to question 6.

8. Are such lands found to be very productive when reclaimed?

Such lands, when reclaimed, are more productive than uplands.

9. Are the water-soaked, boggy, and swampy lands deemed to be prejudicial to health?

They are. Settlers are found along their borders everywhere, but strangers fear them. Their salubrity is everywhere questioned, and in some places it is demonstrated that they are not healthy.

10. Does the reclamation of these lands enhance their value and the value of lands in the vicinity?

The lands are greatly increased in value—from five to ten-fold, and the discredit they bring upon lands adjacent is also taken away. The damage to uplands from their nearness to swamps and wet grounds is very great, though it is seldom taken into consideration.

11. Is the possibility of reclaiming this class of lands engaging the attention of capitalists and farmers for agricultural purposes?

The reclamation of such lands is attracting attention, as may be seen from the Annual Reports of the State Geologist for 1869, 1870, 1871, which are sent with this report.

12. Do the health authorities or physicians of your State complain of them as insalubrious?

They do. See report of the N. J. Health Commission, pp. 18–23.

13. What kinds of farm products are most profitably cultivated upon such reclaimed lands?

This question is answered in the Annual Report of the State Geologist for 1870—p. 51.

14. Please give references to any acts of your Legislature which have been passed bearing upon the reclamation of swamp lands.

Special laws have been passed for draining particular swamps or marshes, and the works have been carried through successfully. The present drainage works are being done under the law "To provide for the drainage of lands," a copy of which is sent herewith.

15. If you cannot furnish exact data to the above inquiries, please give answers that will approximate the facts.

Where swamp, marsh, or other wet lands are held by a large number of individual owners, there is difficulty in getting them to unite for a general work. Persons owning and living on unimproved and wet lands are not usually very thrifty or vigorous; and they need credit and direction to help them, even in making improvements which are sure to be profitable, in the end. On streams where dams have been built to obtain water power, the ponds which are raised have, in many cases, become damaging to farm lands and injurious to the public health. The adjustment of the property rights in such cases is the source of much complaint, litigation and ill-feeling. When a country becomes sufficiently thick-settled, so that boggy, water-soaked, marshy and swampy or occasionally overflowed lands, are discreditable and so damaging to the neighboring lands or injurious to the public health, such lands should be drained by public authority, and the expense borne in part by the lands drained, and part by the whole property of the district.

(Signed) Respectfully yours,

GEORGE H. COOK,

State Geologist.

Water Supply for Cities and Towns.

In the report of last year, mention was made of our resources for the supply of water, to the thick-settled parts of the State. The magnitude of the interests involved, and the anxiety everywhere felt for a supply of pure and wholesome water, render it important that this survey should use the means at its disposal, to furnish information on this subject. The water which is everywhere found by digging a few feet down from the surface, or which issues from springs, does not come from any hidden source of supply within the earth, but is the rain-water which has fallen upon the surface and then soaked down through the soil and into the wells, or drained off through beds of earth, gravel, or fissures in rock to the springs. Such water is usually clear and sparkling, but it is not as pure as when it fell from the skies, but has in it whatever of foreign matter it could dissolve in its course through the ground. The water of wells and springs in country places, and away from dwellings, may be hard or otherwise impure, but it is not usually unwholesome. In cities and towns, however, it is is soon observed that the water of wells and springs grows impure and unwholesome. The filth thrown upon the surface or run into sinks and cess-pools is allowed to soak into the soil and gradually to reach the wells and mix with the purer water. The water from such wells becomes the cause of sickness, even before it is specially offensive to the senses, but finally it becomes disgusting in smell and is abandoned. Such is the course in all our towns and cities; a long time may intervene before the conclusion is reached, and sickness and deaths may occur in the course of it, but finally it comes. Many such cases of the abandonment of wells have occurred to my knowledge, in New Brunswick. Prof. H. B. Cornwall, of Princeton College, has furnished me the results of analysis of several well-waters in Princeton. They show plainly enough the impurities which have got into the water by draining through the ground about dwellings. In his communication he says, "I send you some analysis of well-waters in our town. The results show in nearly every case where a well has been suspected, owing to the nature of the sickness prevailing among those using it, that the well has been worthy of suspicion. My experience with our wells, and no doubt it is the same in every closely built town, has shown that cess-pools, vaults and wells are crowded together too closely to admit of obtaining pure water; but wherever care has been exercised in locating the well plenty of excellent water is to be had. Our people ought to use more cistern-water and less well-water, and there would be less sickness.

"In making the analysis I have followed Wanklyn's method, with the Nessler test for ammonia.

Analysis of Well Waters in Princeton, N. J., February and March. 1875.

	Free Ammonia. Parts per Million.	Albuminoid Ammonia per Million.	Chlorine Grains per Gallon.	REMARKS.
1	1.36	0.28	8.5	Very bad water. The high amount of chlorine and free ammonia indicate recent contamination from neighboring privy vaults. Much typhoid fever has prevailed among people using No 1. No. 2 is not used. It is an example of the careless way in which wells are located, as an abundance of good water might be had on this lot by properly selecting the ground.
2	2.56	0.22	7.4	
3	0.04	0.14	3.6	These wells are suspicious. No. 3 is almost certainly bad. The comparatively small amount of free ammonia indicates contamination by soakage through ground contaminated by old privy vaults; which is, in fact, the case. Diarrhoea is frequent among strangers using No. 3, and typhoid fever has prevailed to some extent among persons using No. 4, although it cannot, with certainty be attributed to the well water.
4	0.054	0.098	2.7	
5	0.04	0.07	2.9	Two samples of fair well water. Both receive some surface water, which accounts for their being less pure than the two following. No sickness attributable to water occurs from their use.
6	0.045	0.064	2.7	
7	0.048	0.05	2.3	Two very pure well waters. Neither of them receive any surface water, and both are located so that the strata dip from them toward the cess pools, situated at a reasonable distance.
8	0.016	0.036	2.0	
9	0.21	0.28	1.9	A bad well, but it is not easy to ascertain the reason. The low amount of chlorine does not indicate sewage impurities. The well is close by the kitchen door, and probably receives some of the slops containing animal matter. It is a deep well with little water at the bottom. Probably only needs cleaning and care to keep away surface water. The occupants of the house are troubled with fevers of a typhoid nature.”

In January of this year an application was received, first from citizens, and afterwards from the city authorities, for an examination of the water supply of Atlantic City, and an opinion as to the qualities of the different samples sent.

The waters were examined and a report made at once, and afterwards I went to Atlantic City and saw their surface wells, their Artesian wells and their rain-water cisterns.

Water sufficiently fresh for drinking is obtained on all the sand beaches along the sea shore of New Jersey, by digging holes two or three feet deep in the hollows between the hillocks.

Wells, as they call them, are made by sinking a barrel or hogshead, from which the heads have been taken out, into the sand to the depth of from two to six feet, and removing the sand from the inside of the cask. The water rises in the inside of the cask to within a foot or two of the top, and the well is complete. It needs no bucket or pump, and is usually without cover or curb, so that the water can be dipped out with a pail. Wells of this kind, situated so that water from the sloughs, or from the sea could not readily soak into them, were considered to be good enough, when but few people lived on the beaches, but as population increased, and waste matter, refuse and filth of every sort accumulated, upon the surface, the products of their decay would naturally be carried into the sand with the rain, and so find their way into the wells. The necessary consequence of drinking water poisoned in this way was soon seen in the increased sickness and mortality among those who used it, especially in summer and autumn. The first and easiest means of supplying *pure* water, was to collect rain, from roofs, into cisterns, and it has been resorted to with most satisfactory results. The large hotels, and the better class of houses, are being provided with cisterns, and are able to store water enough for all purposes of domestic consumption; and wherever such water is used there is an entire exemption from the diseases which afflict those who use water contaminated with putrefying organic matter. Cisterns, however, are not provided for the poorer class of dwellings, or for fires, or steam, and the attempt was made to obtain a more abundant supply of water by sinking Artesian wells. As early as 1858 the late Manasseh McClees sunk a well one hundred and eighty-five feet deep, at Cottage Retreat, between Atlantic and Pacific avenues, and near the light-house. The ground was about six feet above high-water mark. The materials passed through were—

Fifty feet beach sand.
Five feet blue clay, like marsh mud.
Thirty feet beach sand.
Five feet very tough blue clay and salt water.
Ninety feet sand, more or less coarse; water salt.
Five feet clay, yellow and blue in streaks; water salt.
Beach sand and salt water.

The boring was lined with an iron tube eight and a-half inches in diameter. The whole cost of the well was $1000, which of course was a total loss. In 1874 the Atlantic City Gas and Water Company sunk two Artesian wells upon the middle of the beach, at the south end of the city, and on ground eight feet above high water. One was sunk ninety feet and the other one hundred and eighteen feet. The material passed through in the first well was reported to be—

Sixty feet beach sand.
Fifteen feet mud and sand.
Fifteen feet beach gravel, and fresh water.

The material passed through in boring the second well was—

Fifty-six feet beach sand.
Five feet black mud and sand.
Fifty-seven feet beach sand, gravel and fresh water.

The wells were tubed with twelve inch iron pipe, and the water rose in them to within ten feet of the surface. A steam pump was applied, and water drawn for twenty-four hours steadily, without lowering it more than three feet in the tube. A gallon of Artesian well water, on evaporation, left $24\frac{30}{100}$ grains of solid mater. This was mostly in the form of mineral carbonates, and no nitrates, or ammonia were found in it. The water was clear, and without smell when examined, though persons, present when the pumping was going on, say that it then had a disagreeable smell, which was perceptible at the distance of sixty feet.

Water from the well of J. Adams, which is one of the best surface wells in the city, on being analysed, was found to contain 15.74 grains of solid matter in a gallon. It contained less of carbonates, and more of sulphates, and a trace of nitric acid. The water was slightly yellow, and the solid matter, when burned, gave off a strong but not unpleasant odor.

The rain water was, of course, unexceptionable.

The water from the surface wells there is contaminated with organic matter, and it is unsafe to use it. That from the Artesian wells is palatable and contains no poisonous organic matter. I think there would be risk in depending upon it for a full supply; for it is apparent from the three borings that the material of the beach is the same from the surface to the bottom of the tubes, and if the wells are drawn hard the water from the sea is likely to be drawn in and spoil them, as it evidently did in the McClees well.

The safe and economical plan is to provide rain water for domestic purposes, and to construct large surface wells for supplying water for fires, and other purposes not requiring pure water.

An abundant supply of pure and excellent water can be had from Absecon Creek, which is a considerable stream on the main land opposite to Atlantic City. The expense of bringing this water across the marsh would be heavy, and may delay the execution of the work, though it will finally be done. It was intended to present here an analysis of the water from Absecon Creek, but it has not been received as expected. Instead of this, an analysis of water from Lawrence Brook, near New Brunswick, is presented. The water is of the same general character with that from Absecon Creek, and from any of the streams to the south of this. If there is any difference, it is, that they are purer. This water is used for the supply of New Brunswick, and its quality is unexceptionable. The analysis was made by Prof. F. C. Van Dyck, of Rutgers College.

"The water supplied to the city of New Brunswick has a dark amber color, a pleasant taste and is very soft. When boiled down it deposits a light reddish sediment. Examination proves this to be organic matter, probably derived from the swamps in which the water first accumulates.

"For technical purposes it is superior to any other water to be obtained in this vicinity. Steam boilers last a much longer time than before this water was introduced, and engineers speak of the brightness of boiler flues even after years of its use. An inspection of the subjoined analysis will account for this freedom from corrosive action. It will be noticed that the chlorine and sulphuric acid are accompanied by sufficient sodium and calcium to fix them in combinations not decomposed by ordinary heat, while in many natural waters these acids are in combinations which readily yield their acids to the iron of boilers. Moreover, the quantity of mineral matter is surprisingly small, not amounting to two grains per United States gallon. The fitness of the water for household use is dependent upon its softness, which makes it economical for washing purposes, and its freedom from sewage contamination.

"Analysis failed to detect any of the impurities usually derived from sewage; it contains no nitrates, nor any free or albumnoid ammonia, which are the substances considered to cause water to be unwholesome.

"Experiment seems to prove that this water has little or no action on lead pipes, but it should be stated that the trials were made with pipes which had conducted the water for two or three years. Either the water has no action on lead, or a protective coating is spontaneously formed.

"Appended is the analysis, giving the parts of each constituent, in one million parts of water.

ANALYSIS.

Solid residue dried at 212° Fah.	60.5
" " at a red heat	32.0

The weight lost in burning was humus.
The solid residue at a red heat is composed of:

Silica	4.50
Oxide of iron	2.25
Alumina	1.25

Lime (as carbonate)	11.25	
Magnesia	1.62	
Sodium chlorine	4.50	
Chlorine, otherwise combined	.55	
Sulphuric acid	4.29	
		30.21

"The above is in one million parts of water; if expressed in the ordinary form of per centage, the fixed residue would be 0.0032 per cent. of the whole.

"The sample was taken from the supply pipes in the city in September, when the water would be in its most impure condition."

The examinations and conclusions regarding the water supply to Atlantic City are equally applicable to all the beaches on our coast, from Long Branch to Cape May.

The question of a supply of wholesome water to the cities of Newark, Jersey City, and other towns and villages in that thickly settled part of the State near New York city, was referred to in last year's report, and an abundant supply of the purest water was shown to exist in the mountainous country in which the Passaic and its branches rise. Both Newark and Jersey City get their present supply by pumping water from the Passaic, only a short distance above the former city. This water is of questionable purity; the city of Paterson, with its 33,000 inhabitants and its numerous factories, is only thirteen miles above Newark, and all its sewage is discharged into the Passaic, and the country from Paterson to Newark is very thick-settled, and the river receives all its wash and drainage. The sewage of Newark, too, though emptied into the river lower down, is yet carried up by the rising tide almost, if not quite to the pumping-works, so that it may help to pollute the water pumped to supply these cities.

Some have maintained that sewage largely diluted with water is oxidized by the air in running a short distance, and that water purified in this way is clean enough to drink, without injury to health. This, however, has never been proved, and the evidence of smell in warm weather is altogether against the assumption.

It is unfortunate that we have no series of reliable statistics of disease and deaths in the different parts of our State, from which to prove anything absolutely, on this question. The evidence collected in other countries on water supply, is, however, very full, and the conclusions reached are clear and safe. In that collected by the English Royal Commission on Water-supply, Dr. Frankland says: "There is no process practicable on a large scale by which that noxious material (sewage matter) can be removed from water once so contaminated, and therefore I am of opinion that water which has once been contaminated by sewage or manure matter is henceforth unsuitable for domestic use." And Sir Benjamin Brodie says: "I believe that an infinitesimally small quantity of decayed matter is able to produce an injurious effect upon health. Therefore, if a large proportion of organic matter was removed by the process of oxidation, the quantity left might be quite sufficient to be injurious to health. With regard to oxidation, we know that to destroy organic matter the most powerful oxidizing agents are required; we must boil it with nitric acid and chloric acid, and the most perfect chemical agents. To think to get rid of organic matter by exposure to the air for a short time is absurd."

Mr. Simon's report on the cholera epidemics of London in 1848–49, and 1853–54: "When the Lambeth Company took its water from the Thames near Hungerford Bridge, the people who drank that water died at the rate of 12.5 per thousand. When the source of supply was removed to the Thames at Thames Ditton, the mortality was only 3.7 per thousand, while at the same time, and in the same districts, the mortality among the people who were supplied with water by the Southwark Company from the Thames at Battersea was at the rate of 13 per thousand."

These statements are sufficiently strong, and from sources near enough to command attention.

Profs. Henry Wurtz and Albert R. Leeds, of Hoboken, have made extended and careful examinations of the Passaic river water, and the results have been published by the authorities of Newark and Jersey City. Prof. Leeds also read a paper on the subject, before the State Sanitary Convention, at Newark, in October of this year. They prove that the water is remarkably free from mineral impurities, and are of opinion that it is, as now taken, safe to use for household purposes.

Gen. E. L. Viele, of New York, takes the ground that the water as now supplied to Newark and Jersey City is unsafe to use. And at the Sanitary Convention in Newark he read an elaborate paper on the water supply for Newark, Jersey City, and other towns in the vicinity. This paper was accompanied by a good map of the whole country to be supplied. He showed the sanitary and economic advantages of taking the water from the Passaic at Little Falls, above Paterson, and more than one hundred feet higher than the present pump-works.

The general question of water supply is, in the present rapid growth of our State, of great importance to all our people, and the special case above mentioned is of vital interest to nearly one-third of our whole population. It is certain that in this case an abundant supply of water of unquestioned purity can be had from the upper Passaic or its branches, and by proper storage this supply can be had without materially affecting the water rights at present in use.

In view of the sanitary importance of preserving pure water for domestic use, some legislation should be had by which streams used for water supply may be protected from pollution by sewage, manufacturers' waste, filth, or impurity of any kind.

6.

LABORATORY WORK: REGULAR AND MISCELLANEOUS.

The Laboratory is kept open constantly. Examinations and qualitative analyses of specimens collected in the explorations of the survey have to be made; quantitative analyses of clays, ores and limestones are made for the egular reports of the survey; analyses of fertilizers are made for the State Board of Agriculture, and numerous tests and partial analyses have to be made in preparing replies to the many applications for information regarding specimens sent from all parts of the State. A moderate charge is made for the analysis of fertilizers, and a similar one might be made for the analysis of ores and minerals. These charges, however, are not sufficient to meet the expense of making the analyses, and as we claim the right to publish the results for the public benefit, it is judged to be fair and useful to expend a portion of the funds of the State in this way. The good effects of it are already shown in the improved quality and uniformity of the fertilizers sold in the State. The information in regard to ores has in some cases stimulated to further and more intelligent work, and in other cases has saved much waste of time and money that would otherwise have been wasted in fruitless explorations.

The publication of the analyses of our soils has attracted the attention of the eminent English agriculturist, J. B. Lawes, esq. And in a letter in which he refers to the soils of Sussex and Warren, he says: "I notice the high per centage of potash, which you give in the analysis of many of your soils. We have no such analyses, showing so high a result as four or five per cent. of potash." The owners of those remarkably productive soils have long experienced the advantages they enjoy; and it is to them, as well as to all our farmers, both satisfactory and suggestive to know a reason for it.

Miscellaneous Analyses and Examinations.

1. Magnetic iron ore, sent to the State laboratory by Philip George, Ringwood. This was taken from a new line of openings west of the Ringwood mines, and about half way between Ringwood and Greenwood Lake, Passaic county. These are reported as indicating a more continuous vein and lacking the short, shoot-like out-crop, characteristic of the group at Ringwood. Several holes show a vein four to six feet wide, of ore rather lean, but of superior character.

The examination showed (.058) fifty-eight thousandths of one per cent. of phosphorous and no sulphur. It can probably be used for Bessemer pig metal.

2. Magnetic iron ore from P. C. Bloom, near Little York, Hunterdon county. It contained:

Insoluble in acid, (rock)	49.7 per cent.
Metallic iron	37.5 " "
Titanic acid	4.7 " "
Phosphorus	Trace.
Sulphur	Trace.

These figures show a lean one, but remarkable for the per centage of *titanic acid* and the *traces* only of phosphorous. The ore was reported to form a workable vein.

3. Magnetic ore, sent by the Pequest Mining Company, from the Bayard property, near Alamuchy, Warren county, for J. B. Venable. The results of a partial analysis were:

Insoluble matter (rock)	26.6 per cent.
Metallic iron	49.5 " "
Titanic acid	5.9 " "
Phosphorous	Trace.

This is another titaniferous ore, and also remarkable for the small amount (trace only) of phosphorous.

These analyses, together with many others made in previous years, indicate this curious relation between titanium and phosphorous, that a considerable per centage of the former always consists with a *very small* amount of the latter. The behavior of such ores in the blast furnace and the character of the product might be an interesting point in the metallurgy of iron, and the chemical examination of iron ores, to test further this hypothesis or substantiate these facts, ought to be continued.

4. Several specimens of ore, said to contain manganese, from the Hoff mine, near Port Oram, Morris county, have been examined. No manganese could be detected in them. This result appears to confirm the generalization in the Survey Report for 1873, viz., that there is a belt of manganiferous iron ore on the northwest—the Pequest Belt—and in the ores of the other belts this element occurs very rarely in any weighable amount.

5. Sphalerite or zinc blende (sulphide of zinc). This mineral has been found on Philip Raub's farm, 1½ miles northwest of Oxford Furnace, Warren county. It occurs in small crystalline aggregates, irregularly disseminated through a greyish white limestone, and associated with magnetic iron ore. The pit from which the rock containing this mineral was taken, was dug for iron ore. A small vein of brownish black ore, partly earthy, was found in the crystalline limestone, with ore irregularly scattered through this rock. Parties from Pennsylvania have leased the property with the intention of searching for zinc ore. The amount of blende is very small, and not sufficient for working, but the discovery is very important, as it is the fourth zinc locality in this range of white limestone belonging to the Pequest Belt, and it is the first ore found anywhere southwest of the old Andover mine. Taken together, the isolated zinc ore localities appear to belong to a very narrow range, the exact location of which is, in the present state of our topographical surveys of this part of the State, only hinted at on our geological maps. A more thorough survey of the topographical features of this county will no doubt define the limits of these zinc ores and manganiferous iron ore belts, and thus plainly mark out the areas in which prospecting may be done with success.

6. Blue limestone sent by S. T. Scranton, of Oxford Furnace:

	1	2	3	4	5
Ins. Matter	3.9	2.2	3.2	2.6	3.7
Carbonate of Lime	52.6	52.0	92 7	51.6	53.9
Alumina and Oxide of Iron	0.6	0.8	0.3	1.0	1.9

These limestones were from Warren county, from Pace's quarry, near the Pequest river, north of Oxford Furnace, from the quarry at Changewater, worked for the Oxford furnaces, and No. 3, from the Warren Railroad cut, about a half mile east of Washington. Nos. 1, 2, 4 and 5 are common magnesian limestones, and the per centage of lime is about the same in each of them. No. 3 is darker blue in color, and finer grained, and is a pure limestone. The outcrop of this latter variety, as is seen in the railroad cut, measures ten feet, and it is bounded on the west by a rough. knotty-looking blue limestone, in thick beds, traversed irregularly by calcite veins, while on the east there are only ledges, here and there, of ordinary blue limestone, covered by a yellow clayey earth. The difference in the appearance of these varieties is so great that they are clearly defined in extent. This mode of occurrence of pure limestone, imbedded in the magnesian stone, has not been observed elsewhere. The great value of such stone suggests a more careful survey of all blue limestone outcrops, to determine their character, and the probable extent of both the magnesian and pure limestones. The development of our natural resources, and the corresponding utilization of them all, to the greatest extent and with the greatest economy, will, in the not distant future, make use of all these pure limestone outcrops of the State, for the manufacture of superior lime.

The specimens were analyzed with reference to their value as fluxes in the blast furnace. For such purpose there is a diversity of opinion both among scientific metallurgists and among practical iron workers. And location favorable to economical working is, perhaps, more important than composition. So that magnesian limestone will continue to be preferred, where they are cheaply got, to those without magnesia.

7. Clay from the bank of the Wallkill river, Drowned Lands, Orange county, near the New Jersey line. Sent to the State Laboratory by M. F. Ten Eyck, of Warwick, New York:

Silicic acid, in combination	28 9
Quartz	22.9
Silicic acid, free	1.2
Titanic acid	0.5
Alumina.	23.1
Peroxide of iron	7.2
Water	9.7
Lime	0.7
Magnesia	2.6
Potash	4.1
Total	100.9

This clay is said to exist in large quantity, forming a thick layer at this point in the alluvial district of the Drowned Lands, and probably underlying much of the black muck surface of this tract.

The specimen sent was thoroughly air-dried, and was slate-grey in color, and showed a little fine gritty sand. It contains too much oxide of iron and potash for any refractory or fire materials. Washing out the fine sand might enable it to be used in some styles of paper facing. It is most interesting as the basis of a valuable, enduring and fertile soil, and, if properly drained, it would be unsurpassed for tillage or pasturage; and as such it furnishes another argument for the drainage of this tract of Drowned Lands.

The mining industry of the State partakes of the depression so general in all branches of business. And that portion devoted to iron mining is more seriously affected in consequence of the stagnation in the *manufacture of iron.* During 1874 many of the companies kept their force of labor in the mines nearly, if not quite, equal to that of 1873, hoping for a revival of business and a better demand for ore, and thus to be ready to reap the first results of such improvement, and also to keep their mines in a good working condition. This, in part, explains the comparatively small decrease in the amount of iron ore mined last year as compared with that of 1873. During this year there has been a marked change. The continued lack of demand has discouraged work, and in nearly all the large mines the mining force has been reduced to a minimum consistent with keeping them from suffering injury by an entire stand-still. Several of the large companies have stopped altogether. The smaller mines and individual enterprises are doing even less than the companies. We have no figures of ore mined for the year up to date, but from a careful survey of the iron-ore district it is very certain that the reduction in the product for 1875, compared with last year, will greatly exceed the loss in 1874. As many of the furnaces are out of blast, the stock at the mines is generally much greater than ever before. In some cases the accumulation is at the furnaces. So that, altogether, there is a large amount of ore ready for them whenever the demand for iron shall call for it. One company is reported as having one hundred thousand tons of magnetic ore stocked. And there is probably as large an amount now on the bank at a-half-dozen of our larger mines.

In the midst of this almost universal depression there are some marked exceptions. These are doing quite as much as in any previous years while there a few newly opened localities which are being quite actively worked. In a few cases there are special business arguments which are driving them. But in the most of them we find the superior character of the ore—its adaptation to the manufacture of iron for Bessemer steel—claiming a market for it and enabling its owners to keep at work. Such ores are wanted and command remunerative prices, and mines having such can be worked profitably and vigorously even in these times. It would probably be invidious here to enumerate, if it were possible, the mines which are furnishing Bessemer ores as they are known to the iron men generally. It is, however, eminently proper to state here that we are not yet fully acquainted with even the best known mines so as to say in advance of chemical examination, what ores may or may not be suitable for Bessemer steel. Our knowledge of the geological structure of the iron ore district is yet too incomplete to enable us accurately to locate all the ores free, practically, from phosphorous. Hence the urgent importance of ascertaining at all times, and especially at the present, what are the capabilities and values of the ores raised in all of our mines. The force of this becomes more apparent by a reference to the past. Only a few years ago there was scarcely any ore mined in the State which was supposed to do for making into steel. We had no Bessemer ores on account of the *assumed* universal presence of too much phosphorous. Chemical analysis followed by experiment and routine practice have upset this wrong conception so much that in 1874 several furnaces made steel pig, running on New Jersey magnetite. Their success has started the examination of known ores and stimulated prospecting in search of new mines of the same character.

And every mine owner should consider this matter and examine his ores. A reference to the reports of previous years will show that there are several localities in the State where such ores occasionally occur in workable beds, and they ought to be tested. It was stated in the report for 1873 that the ores found in the northwestern or Pequest belt were characterized by the presence of manganese, and further the analysis of several of them showed low per centages of phosphorous.

That this character will be found to be true, generally, there is little doubt. Here then is a belt of country where the prospector has a field for his operations, and success in it will lead to work and demand for his product. But this generalization is not confined to this belt. The analyses given in this report exhibit onl traces of phosphorous. Further surveys and chemical investigations may bring out a series of ranges of ores containing no phosphorous. In view of the future increasing and wider use of steel over that of iron there is the strongest probability that all ore which can be used in its manufacture will find a more ready sale and greater demand than the ordinary ores containing phosphorous, unless some process, efficient and practicable, can be found which will remove this element so prejudicial to the highest value of iron. In the old method of iron making in the Catalan forge, our ores which had a comparatively large amount of phosphorous in them were used and made excellent bar iron. In this mode of manufacture the phosphorous nearly all went out in the cinder, whereas now, in the more intense heat and greater reducing action of our high blast furnaces, it is released from its combination as existing in the ore and enters the iron. It should here be stated that in the magnetic iron ores of New Jersey the phosphorous is combined with lime, forming the mineral *apatite*, or phosphate of lime, which mineral is only mixed with the oxide of iron of the ore. The grains of *apatite* are plainly seen, and in the small way can easily be separated or picked out. Any method which can be discovered of separating this mineral from the magnetic either *before smelting, by some roasting process*, or by causing it to go out in the cinder, will allow of the use of nearly all of our ores in making steel, and work a great change in iron metallurgy, and add *very* largely to the industry of our State. No field seems more tempting to the inventor, and we cannot conceive of any more marked or valuable step in the metallurgy of iron than this would be, nor of one more to be desired. The subject deserves the attention of scientific as well as practical men, and further, of all who are interested in the development of the resources of our State. And when we consider how the great difficulty in the practical use of sulphurous ores has been overcome we feel confident that the inventive genius of our iron workers will yet solve this problem.

The ores which formerly were considered almost worthless in consequence of the large amount of sulphur in them are now successfully used, the removal of the sulphur being effected by treatment in roasting furnaces previous to going to the blast furnace. One of the latest forms of such furnace has been designed and erected by Wm. Taylor, formerly of High Bridge, at Chester, Morris county. This is said to do the work effectually and very cheaply, besides putting the ore in a better condition for smelting than in its raw state.

GEORGE H. COOK,
State Geologist.

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